International Journal on Ageing in Developing Countries, 2020, 5 (2): 182- 200

Classification of sub-regions worldwide by quantum and tempo of population ageing: Focus on the less developing countries

Marta Mustafina[1]

Abstract. Population ageing is an unprecedented phenomenon happening on a global scale (United Nations, 2020). Many existing studies analyse population ageing in both developed and less developed countries. The research on quantum and tempo of ageing, however, is scarce. The aim of this research paper is to answer the question of how sub-regions and selected countries in the world are differentiated in terms of the quantum and tempo of population ageing based on the data for the period 1950–2100. The research results showed that European sub-regions, Northern America and Australia/New Zealand experienced the lowest quantum and tempo of population ageing. Western Asia along with selected countries including Albania, Afghanistan, Singapore and the United Arab Emirates are in turn estimated to experience the most intensive processes of ageing. The findings of this work have demonstrated that the less developed countries are ageing with a higher speed and intensity which requires timely policy action to mitigate the negative consequences of the phenomenon and utilize the emerging opportunities.

Keywords: population ageing, demography, world, sub-regions, less developed countries, more developed countries.

Introduction

"We are ageing – not just as individuals or communities but as a world" (National Institute of Aging & U.S. Department of State, 2007:4). The process of population ageing is the direct outcome of demographic transition which is expected to be experienced by each and every country worldwide (Dyson, 2010; Kirk, 1996). The extent of the demographic changes taking place during the demographic transition varies among the countries but they follow more or less analogous pattern of declining death rates followed by the declines in birth rates (Pavlik, 1980; Reher, 2004). While it is widely accepted that mortality decline is the first driving force behind the demographic transition, the opinions regarding the main determinant behind the

[1] Department of Demography and Geodemography, Faculty of Science, Charles University, Prague, Czechia (marta.mustafina@natur.cuni.cz)

process of population ageing are not quite unanimous. The earliest reference of age structural determinant usually refers to Coale (1956), who concluded, using the stable model, that fertility decline plays the dominant role in population ageing. Kinsella (2000) and Wilmoth (2015), for instance, also state that the ageing process is primarily driven by fertility while mortality decline is secondary. Even though, the aforementioned conclusion remains to be a classical view on the primary determinant of the ageing process, recent empirical evidence suggests that since the second half of the 20th century mortality improvement in older ages has come to contribute significantly to the age structural changes resulting in the ageing of populations (Caselli & Vallin, 1990; Murphy, 2017; Preston & Stokes, 2012; Preston, Himes, & Eggers, 1989). The impact of replacement migration on population ageing is found to be quite minor in general (Burcin, Drbohlav & Kucera, 2005; United Nations (UN), 1973; 2011), albeit Kinsella and Phillips (2005) argue that international migration can play a significant role in smaller populations, namely, some parts of the Caribbean. Nevertheless, it is important for policy makers, especially in the less developed countries with observed heterogenous demographic trends, not to base conclusions on generalized statements about the determinants of population ageing. There is no 'one-fits-all' worldwide model of population ageing process and each country has to approach the issue on empirical grounds considering its unique socio-economic development.

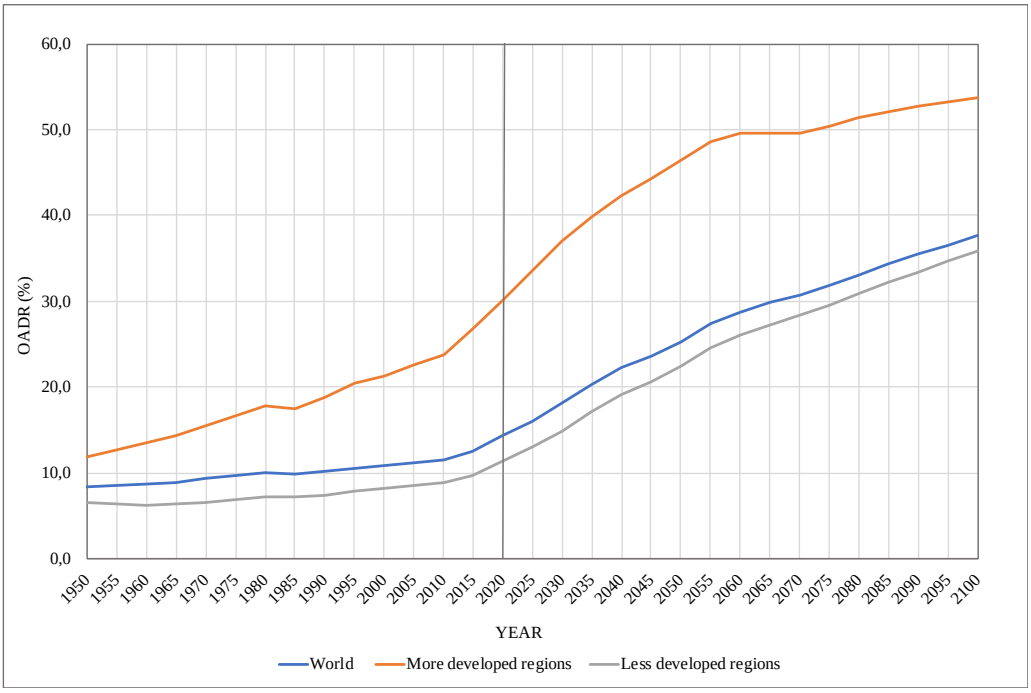
The shift from relatively young to older population structure occurs when the proportion of individuals aged 65 and older expands from 7% to 14% (Harper, 2011; Kinsella, 2000). Based on this notion, according to the United Nations (2019a) estimates, the less developed countries today are at the same stage, as the more developed ones were back in the beginning of the 1950s, with just over 7%. The population in the less developed countries is estimated to become 'old' by mid-century reaching around 14.2%. Nearly every fifth person in the more developed countries is aged 65 and over today, while by 2050, the proportion of older persons is projected to increase to one quarter of total population (ibid.). In Japan, one of the countries with the oldest age structures in the world, individuals aged 65 and over already comprise over a quarter of total population today (Statistical Handbook of Japan, 2019).

Older population around the world is growing both in relative and absolute terms. The most rapid growth, in its turn, belongs to the proportion of oldest old (80 and over) among the older population (European Union (EU) 2018; United Nations, 2019a). Based on the United Nations (2019a) estimates, in 1950 the proportion of population aged 80 and over in more and less developed countries was just 8 and 6 million in absolute numbers, and a mere 1% and 0.4% in relative terms respectively. In 2019 this population segment has increased to 5.3% and 1.2% (67 and 78 million in absolute terms) relative to the population living in more and less developed countries accordingly, and it is expected to undergo a dramatic surge reaching to as much as 10% and 3.5% respectively, i.e. 129 million and nearly 300 million individuals by 2050. The growth of the proportion of older population is generally associated with the more developed countries, which is true as those countries have relatively high proportions of older persons but this segment of population is actually growing at a much faster rate now in the less developed countries.

Most of the scientists acknowledge that conventional measures of population ageing reflect the process substantially accurately and continue using them in their research. There have also been a number of new proposed estimates and approaches to measuring ageing, most of which are based on the notion of 'tempo effects' introduced by Ryder (1964). Among those are: 'prospective age approach' by Sanderson and Scherbov (2005), later modified by the authors to 'characteristic approach' (Sanderson & Scherbov, 2013) as well as 'tempo adjusted' total fertility rate (TFR) and life expectancy (Bongaarts & Feeney, 1998; 2003). These alternative measures, however, have received critiques from other researchers (Balachandran, de Beer, James, van Wissen, & Janssen, 2019; Guillot, 2006; Luy, 2010; van Imhoff & Keilman, 2000) arguing that the new proposed indicators and approaches require further analysis and are not straightforward measures that can only be used in specific scenarios. In this research paper conventional indicators are used to describe and analyze the process of population ageing.

Figure 1 illustrates that worldwide, the old-age dependency ratio (OADR) was estimated at 14.3% in 2020 compared to 8.4% in 1950 and is expected to increase to 25.3% and 37.7% by 2050 and 2100 respectively. The trend of OADR in the less developed countries follows nearly an identical pattern with slightly lower estimates, where currently there are on average 11 individuals aged 65 and over per 100 individuals of working age. This figure is set to double by 2050 reaching 22 to 100 ratio and more than triple with 36 to 100 ratio by 2100. In the more developed countries, there were already on average 30 individuals aged 65 and over per 100 individuals of working age in 2020. The OADR here is estimated to reach 46 to 100 ratio by mid-century and slowdown in its pace reaching 54 to 100 ratio by 2100.

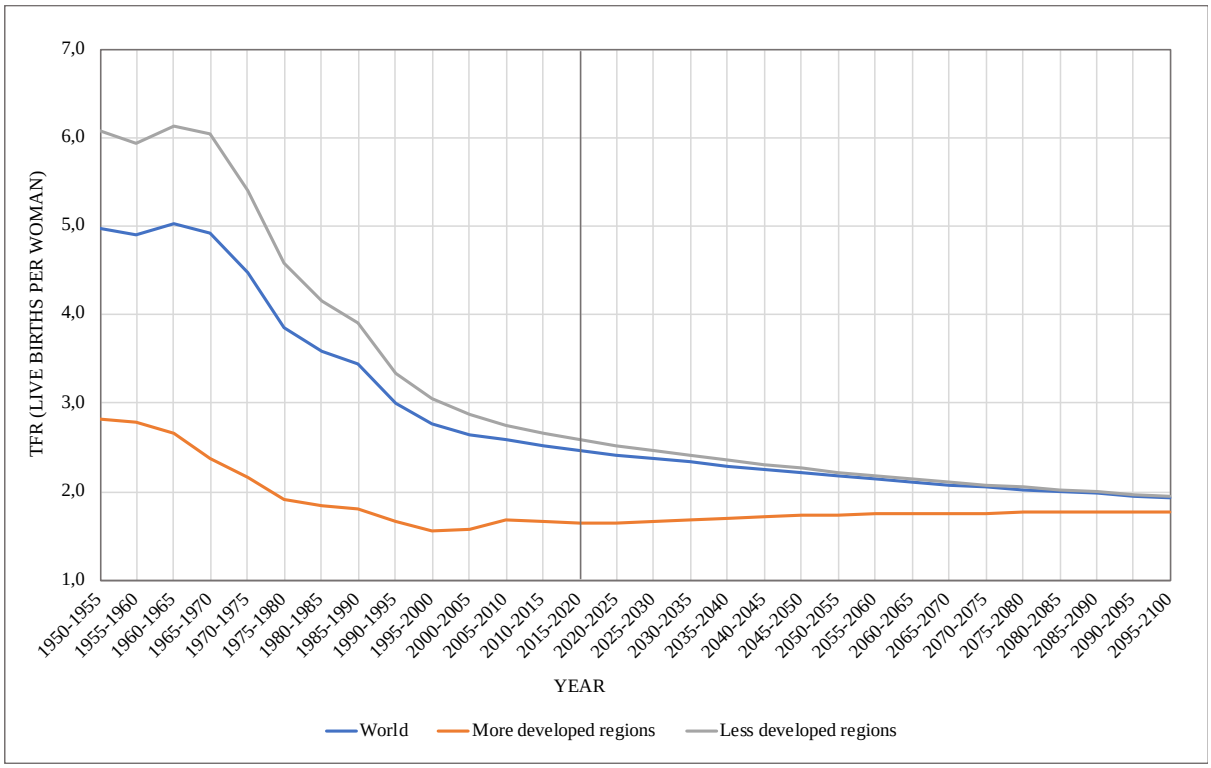
Figure 1: OADR in less developed regions, more developed regions and worldwide, 1950–2100



Source: United Nations, (2019a).

Figure 2 indicates that TFR has been steadily decreasing having dropped twofold over the course of the last seven decades, from approximately 5.0 to 2.5 live births per woman on a global scale. In the more developed countries, average TFR has dropped below replacement level around the year 1975. Global level (2.5 live births per woman in 2020) is kept above replacement fertility due to high rates among the less developed countries. As seen from Figure 2, the fertility rate has, nevertheless, been decreasing at a much faster pace in the less developed countries, which has narrowed the gap with the levels of the more developed countries. Based on the United Nations (2019a) medium fertility projections, TFR in the less developed countries is expected to fall below replacement level around 2070–2075.

Figure 2: TFR in less developed regions, more developed regions and worldwide, 1950–2100

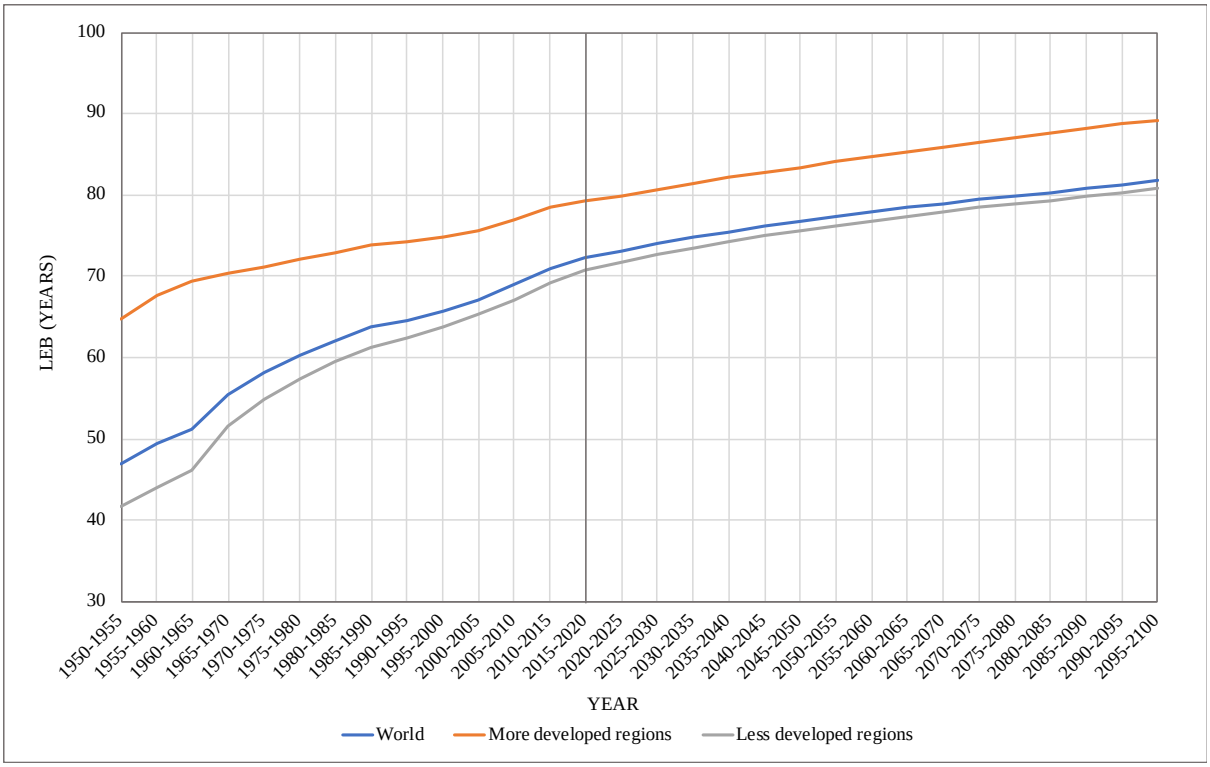


Source: United Nations, (2019a).

Early increase in life expectancy at birth (LEB) resulting from declines in child mortality lead to increased numbers of infants and children as well as reductions in the proportions of older individuals, while continued progress into the later years of the lifespan contributes to the growing proportion of older population as more and more people survive to older ages (United Nations, 2013).

It is estimated that LEB was between 25 and 35 years up until the mid-18th century (Notenstein, 1953; Vallin, 2002). According to Oeppen and Vaupel (2002), Swedish women, for instance, held a record of LEB of approximately 45 years in 1840 which has been steadily increasing by 3 months per year ever since. As further argued by the authors, this linear increase of record lifespan should be seen as a continuing progress resulting from advances in all spheres of life.

Figure 3: LEB in less developed regions, more developed regions and worldwide, 1950–2100



Source: United Nations, (2019a).

In the 1950s, LEB was roughly 65 years in the more developed countries, which was achieved by the less developed countries only in the beginning of the 2000s (Fig. 3). Today, it exceeds 80 years in 39 countries around the world (United Nations, 2019a). The gap between more and less developed countries has reduced twofold over the last decades as a result of rapid increment observed in the less developed countries. A great leap forward is projected by the United Nations (2019a) estimates, as LEB in the less developed countries is expected to nearly double from 42 to around 81 years during the period 1950–2100.

It's been three decades since the UN designated International Day of Older Persons and two decades since the 'International Year of Older Persons' that recognized the phenomenon of global population ageing and its importance (United Nations, 1999; 2019b). Since 2002, the Madrid International Plan of Action on Ageing (MIPAA) has been serving as one of the main international guiding policy instruments on ageing (United Nations, 2002). MIPAA goes beyond theoretical framework on ageing and the progress of its implementation is systematically reviewed every five years since 2007 (United Nations Economic Commission for Europe (UNECE), 2020). Policymakers in the less developed countries have an opportunity to learn from the available best practices and successfully integrated policy measures. Nevertheless, policy action can be effective when implemented vertically across national,

regional and local levels based on the identified age-structural changes and projected trends of demographic changes.

Method

Data availability and quality are one of the core components of any empirical study. The analysis of this work has been mainly carried out based on the data provided by the 2019 Revision of the World Population Prospects (WPP) of the United Nations. It incorporates population estimates and projections for the period of 1950–2100. The base year of the projections is 2020. Medium fertility variant was used in the analysis of this work.

According to the United Nations (2019a), past estimates presented in the WPP 2019 Revision were collected directly from the national statistical sources as well as registries of vital events, demographic surveys, etc. In some instances, the original data was adjusted for deficiencies in age misreporting, under-enumeration or underreporting of vital events. Consistency in the data was achieved through the use of models along with methods of indirect estimation.

Countries have been grouped in sub-regions according to the United Nations classification. The terms of 'more developed' and 'less developed' regions/countries are based on the United Nations definition where the more developed regions constitute Australia/New Zealand, Europe, Japan and Northern America and the less developed regions (including least developed countries) comprise all of Africa, Asia (apart from Japan), Latin America and the Caribbean as well as Melanesia, Micronesia and Polynesia. If not specified, older population is referred to population aged 65 and over in this work. Oldest old population in its turn refers to individuals aged 80 and over.

Based on the United Nations definition accepted by most of the scholars (Harper, 2011; Kinsella, 2000), a society is considered to be 'ageing' when the proportion of older people aged 65 and over crosses the threshold of 7%, while the threshold of 14% denotes already 'aged' society. The quantum and tempo of population ageing in this study was measured as a ratio of percentage point increase in the proportion of population aged 65 and over from 7% to 14%, to the number of years required to reach this threshold.

Two factors have been taken into consideration when classifying sub-regions and selected countries by the quantum and tempo of ageing: the expected time when the proportion of population aged 65 and over would reach 14% (before the year 2050 or during the period 2050–2100) and the level of the quantum and tempo of population ageing (comparatively low quantum and tempo of less than 0.18 percentage points per year, high quantum and tempo of 0.18–0.30 percentage points and very high quantum and tempo of more than 0.30 percentage points per year).

Results

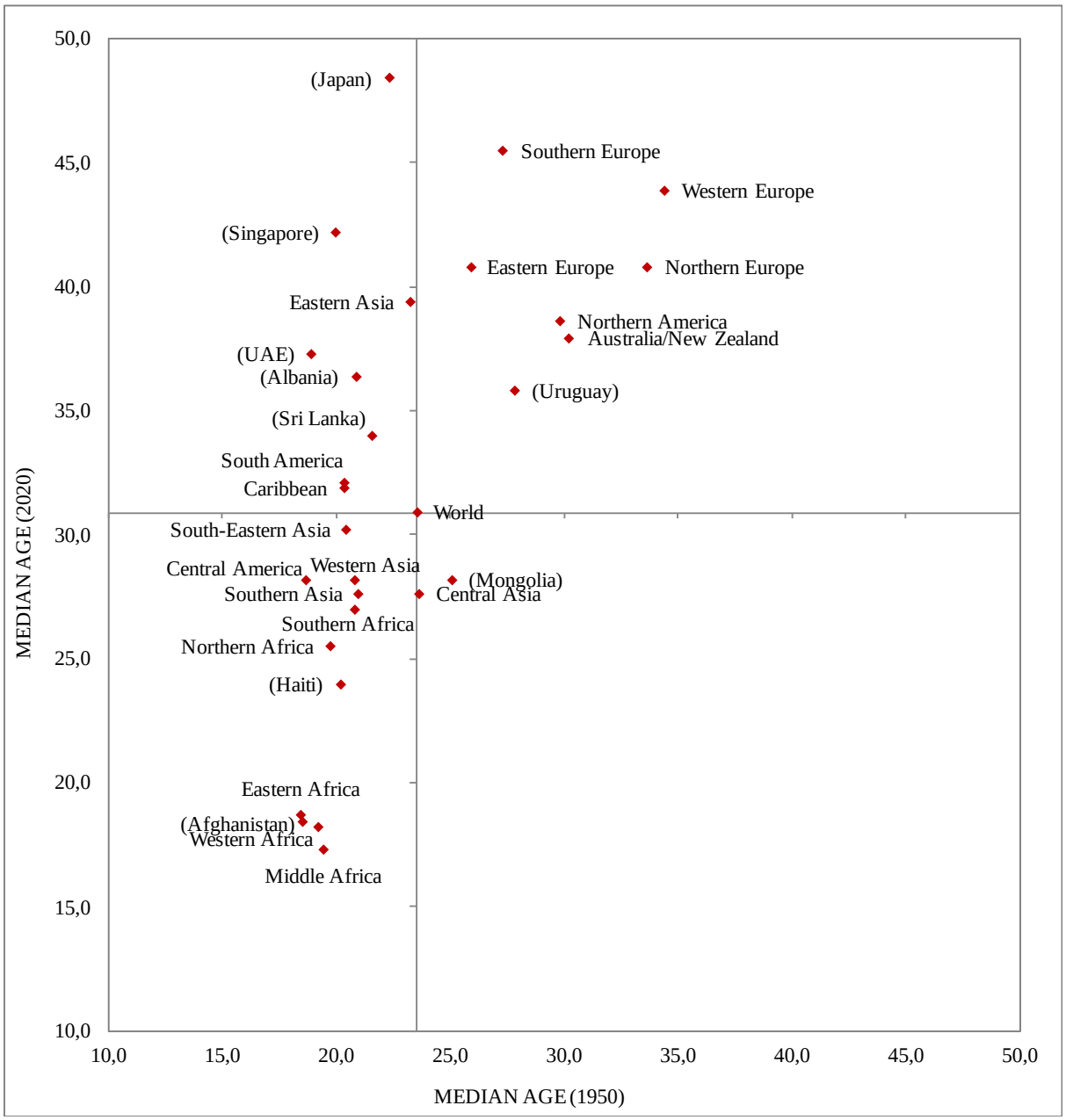
The results of this research are based on the analysis of what is already known as well as identification of future trends of population ageing in terms of its quantum and tempo effects in sub-regions and selected countries worldwide.

The growth of older individuals in absolute and relative terms commenced its acceleration towards the end of the 20th century mainly due to rapid increase that started in the less developed regions. The number of older people has increased by a factor of five between 1950 and 2020 from 129 million to 728 million persons and is expected to reach as much as 1.5 billion by mid-century of which 1.2 billion will be from the less developed countries (United Nations, 2019a).

Shift in the median age of a population is another evidence of population ageing. Based on the United Nations (2019a) estimates, today, the median age of the world population is 31 years which has increased by 7 years since 1950 and is projected to increase by another 5 years towards the mid-century. The less developed countries differ significantly from the more developed countries where the median age of the latter was estimated at 42 years in 2020 which is 13 years higher than that observed in the less developed ones. But the rate of increase in the median age has accelerated in the less developed countries over the past two decades and is projected to reach 35 years by the year 2050. The oldest country in the world with the median age of 48.4 years in 2020 was Japan while the youngest was Niger where the median age was just 15.2 years (United Nations, 2019a).

The breakdown of youngest and oldest sub-regions along with selected countries by the median age in 1950 and 2020 is presented in Figure 4. Selected countries are identified in the analysis as a result of their atypical rates compared to the averages of the sub-regions they belong to. Most atypical cases are observed in Asia as some of its countries have started undergoing the demographic transition with declining birth and death rates considerably earlier which has resulted in higher proportion of older population. The values in the scatter plot (Fig. 4) are relative to the world estimates of the median age of 24 and 31 years in 1950 and 2020, respectively. Sub-regions and selected countries are scattered from the youngest ones at the bottom to the oldest at the top.

Figure 4: Breakdown of sub-regions and selected countries by the median age, 1950 and 2020

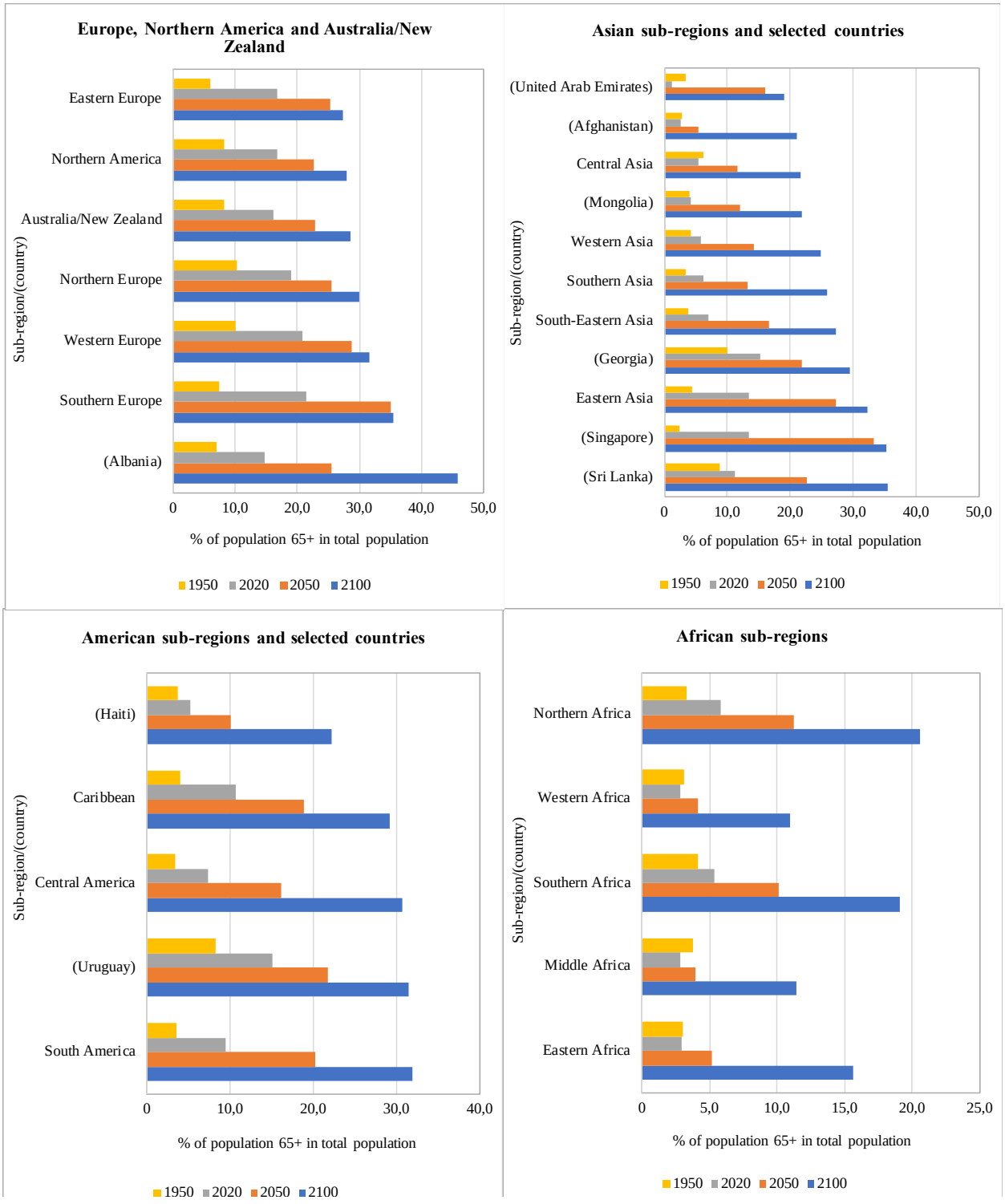


Source: United Nations, (2019a).

Figure 4 shows that European sub-regions along with Northern America and Australia/New Zealand are concentrated in the upper right corner which signifies that countries in those sub-regions were already quite 'old' in the 1950s. Japan and Afghanistan represent two extreme cases where the median age of the latter has remained practically the same while in Japan it has more than doubled. All of African sub-regions are gathered in the lower left corner being among the youngest in the world while Asian and American sub-regions (Uruguay being an exception) are scattered in the left upper and lower parts confirming the heterogeneity of their population age structures.

The quantum and tempo of increase in the proportion of older individuals shows stark differences between more and less developed countries. Furthermore, there are some obvious differences within the less developed sub-regions where some of the countries are at a more advanced stage of population ageing as a result of earlier onset of demographic transition. The more developed sub-regions in their turn show comparatively analogous pace. Figure 5 illustrates the trend in the proportion of older population around the world since 1950 with anticipated estimates towards 2100. Europe is the 'oldest' region in the world. According to the United Nations (2019a) estimates, the proportion of older people in European sub-regions is the highest worldwide with Southern and Western Europe in the lead having had 21.4% and 20.8% of persons aged 65 and over in 2020, respectively. Albania is an exception in Southern Europe where the proportion was considerably lower – 14.7% in 2020 – compared to the average percentage of the sub-region. Yet the rate of increase has been accelerating in Albania, where the proportion of older people is projected to reach almost a quarter of the total population before mid-century

Figure 5: Proportion of population aged 65 and over in sub-regions and selected countries, 1950, 2000, 2050, and 2100



Source: United Nations, (2019a).

Figure 5 further depicts the increase in the proportion of older individuals in Asian sub-regions and selected countries over the course of 150 years (1950–2100). Asian countries are very heterogeneous with regards to the intensity of increase in the proportion of older population. As seen from Figure 5, Singapore is undergoing tremendous acceleration and is expected to have as much as 33.3% of older population by mid-century compared to current 13.4%. Older population in Central Asia is expected to more than double from 5.4% in 2020 to 11.6% in 2050 and again increase two-fold by the end of the century.

American sub-regions (apart from Northern America) are more or less homogeneous in their proportions of older population apart from a few exceptions. This part of the world is rather young but the rate of increase in the proportion of older people has started to accelerate. The proportion of individuals aged 65 and over is expected to nearly double in the Caribbean from 10.6% to 18.8% during the next three decades (Fig. 5). Haiti here is an exception where the proportion is considerably smaller and is not increasing at a fast pace at the moment but this is expected to change from the mid of this century. By 2050, older people in Haiti are estimated to represent only 9.6% of the whole population. South America has somewhat similar rates to the Caribbean. Central America is a bit 'younger' though the proportion is increasing with a higher intensity. Uruguay, in turn, is the 'oldest' country in the region as a result of the historical immigrant population from Europe.

African sub-regions were the 'youngest' ones in 2020 (Fig. 5). Northern Africa has the highest proportion of older population in the region. The increase of older population from 7% to 14% in Southern Africa is estimated to happen in around 38 years from the year 2035 until 2073, while in Eastern Africa it is projected to occur in just 30 years in the second half of the 21st century (2063–2093) and in Northern Africa it should take roughly 42 years (2028–2070). In Middle and Western Africa, the older population is projected to increase up to 7% only by the year 2075 and 2078 respectively and is not expected to reach 14% threshold by the end of this century (Fig. 6).

The proportion of population aged 65 and older in France grew from 7% to 14% in 115 years (1865–1980), in Sweden the process took around 85 years (1890–1975), in Australia – 74 years (1938–2012), and the United States needed 68 years (1944–2012) (Kinsella & Phillips, 2005). Since historical data series of population size by age groups are not available for all of the countries, the data of France, Sweden, United States and Australia will represent the sub-regions of Western Europe, Northern Europe, Northern America and Australia/New Zealand respectively based on the fact that the latest trends of those countries are compatible with averages of the whole sub-regions (Fig. 6). The average data for the whole sub-region indicated that it took Eastern Europe around 42 years (1963–2005) for the proportion of older population to increase from 7% to 14% while Southern Europe required around 45 years (1947–1992) (United Nations, 2019a). Albania being an exception reached the proportion of 7% only in 2001 but it took only 18 years until 2019 to reach the level of 14% which is more than twice faster than in Southern Europe, according to the United Nations estimates.

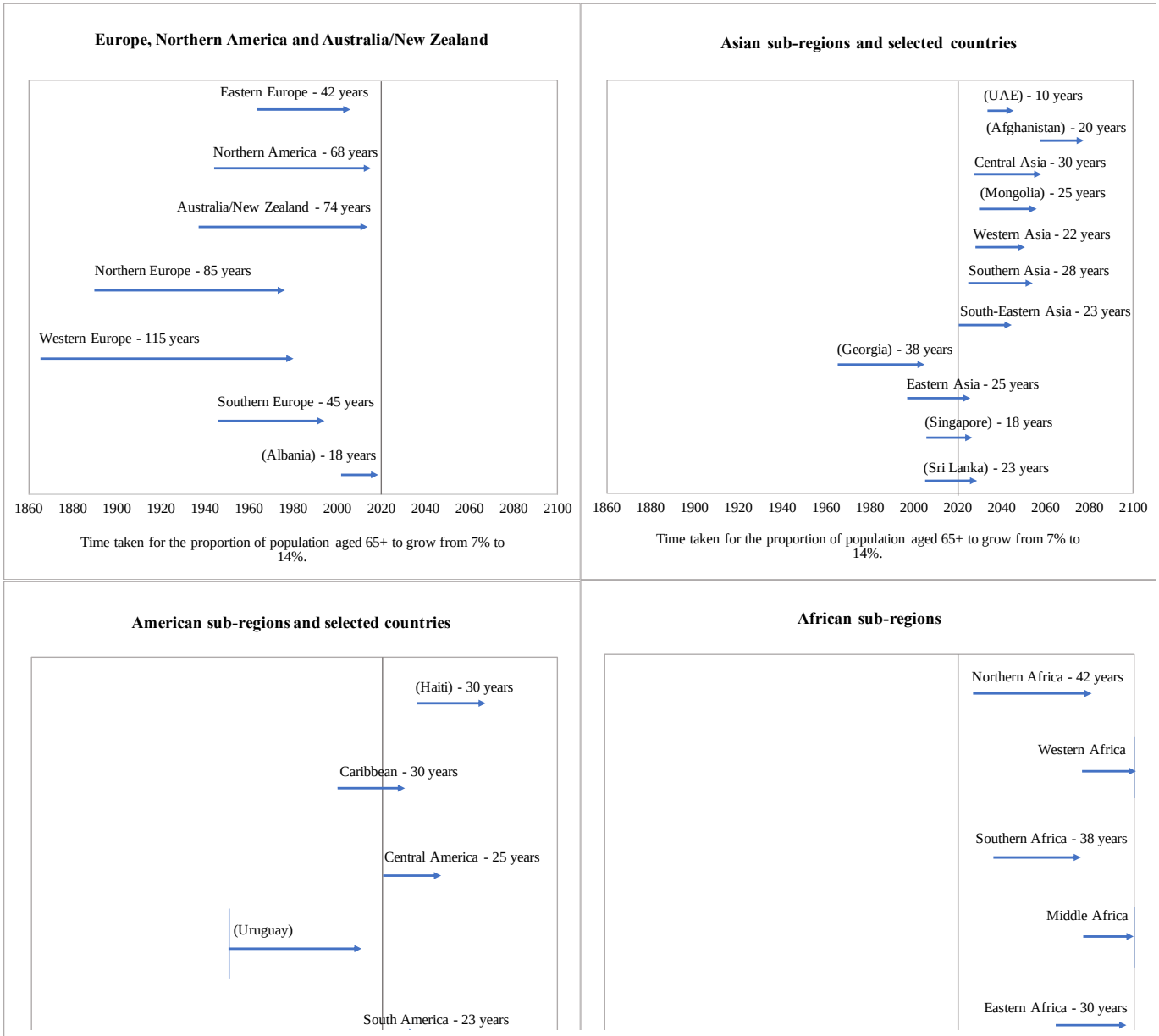
The quantum and tempo of population ageing in Eastern Europe, as a result, is roughly 0.17 percentage points per year, in Southern Europe it is 0.16 (where Albania's quantum and tempo is 0.39 percentage points), while in Northern Europe it is estimated at 0.08 and in Western Europe at 0.06 percentage points. In Northern America the quantum and tempo of ageing is about 0.10 and in Australia/New Zealand it is 0.09 percentage points.

As illustrated in Figure 6, in Eastern Asia the proportion of older persons reached 7% only in 1998 but it is projected to increase up to 14% in mere 25 years. Mongolia is also expected to pass the threshold of 7% through 14% in just 25 years but much later during 2030–2055. The same increment in the proportion of older individuals is projected to happen in Central Asia in around 30 years (2028–2058), while Southern Asia should require 28 years (2025–2053) (where Afghanistan would need only 20 years (2058–2078) and Sri Lanka – approximately 23 years (2005–2028)), South-Eastern Asia – 23 years (2020–2043) (where Singapore is expected to undergo the increase in record 18 years (2005–2023)), and Western Asia in 22 years (2028–2050) (where United Arab Emirates are projected to have the proportion increased in just 10 years (2033–2043) which is a surprising estimate). Georgia was the first country in Western Asia to have reached 14% threshold. It took the country approximately 38 years (1965–2003) which is much longer than the average for Asian continent.

The quantum and tempo of ageing in Eastern Asia is approximately 0.28 percentage points per year. Central Asian population is ageing at a slightly slower pace of 0.23 percentage points. Southern Asia is somewhere in between with roughly 0.25 percentage points per year while it is 0.35 in Afghanistan and 0.30 in Sri Lanka. In South-Eastern and Western Asia, the quantum and tempo of ageing is estimated at 0.30 and 0.32 percentage points per year respectively, while in Singapore it is 0.39 and is as high as 0.70 in the United Arab Emirates.

The quantum and tempo of ageing is considerably high in American sub-regions (Fig. 6). The Caribbean should require approximately 30 years (2000–2030) for the older population to increase from 7% to 14% (where Haiti should also take around 30 years but much later (2035-2065), while in Central America the same increase is estimated to occur in just 25 years (2020–2045) and in South America in about 23 years (2010–2033).

Figure 6: Speed of population ageing in sub-regions and selected countries worldwide



Notes: 1. Data for Uruguay is not available prior 1950.

2. The proportion of population aged 65+ in Western and Middle Africa is not expected to reach 14% before the end of this century.

Source: Kinsella and Phillips, (2005); United Nations, (2019a) and author's calculations.

As a result, in the Caribbean, population is ageing with a quantum and tempo of 0.23 percentage points per year. In South and Central America, it is estimated at 0.30 and 0.28 percentage points, accordingly.

In African sub-regions the quantum and tempo of the ageing process is not as high as it could be expected. Eastern Africa is projected to age with a quantum and tempo of 0.23 percentage points per year and Northern and Southern Africa with as low as 0.17 and 0.18 percentage points, respectively. It is not possible to calculate the approximate quantum and tempo of the ageing process in Middle and Western Africa based on available projections since the proportion of older population is not expected to reach 14% before 2100.

Subsequently, the classification of sub-regions and selected countries by the quantum and tempo of population ageing has been developed based on the results of the analysis of population ageing worldwide (Tab. 1). Six different types of the ageing processes are identified in reference to the quantum and tempo of ageing and the time period when the proportion of population aged 65 and over increased from crucial 7% to 14%.

Table 1: Classification of sub-regions and selected countries by the quantum and tempo of population ageing

Type I – Early ageing with low quantum and tempo Period: before 2050 Quantum and tempo: < 0.18	**Type II – Early ageing with high quantum and tempo** Period: before 2050 Quantum and tempo: 0.18–0.30
• Australia/New Zealand • Eastern Europe • Georgia (Western Asia) • Northern America • Northern Europe • Southern Europe • Western Europe	• Caribbean • Central America • Eastern Asia • Japan (Eastern Asia) • South America • South-Eastern Asia • Sri Lanka (Southern Asia)
Type III – Early ageing with very high quantum and tempo Period: before 2050 Quantum and tempo: > 0.30	**Type IV – Late ageing with low quantum and tempo** Period: between 2050–2100 Quantum and tempo: < 0.18
• Albania (Southern Europe) • United Arab Emirates (Western Asia) • Singapore (South-Eastern Asia) • Western Asia	• Northern Africa • Southern Africa
Type V – Late ageing with high quantum and tempo Period: between 2050–2100 Quantum and tempo: 0.18–0.30	**Type VI – Late ageing with very high quantum and tempo** Period: between 2050–2100 Quantum and tempo: > 0.30

• Central Asia • Eastern Africa • Haiti (Caribbean) • Mongolia (Eastern Asia) • Southern Asia	• Afghanistan (Southern Asia)

***Sources**:* Author's own study based on the data from Kinsella and Phillips (2005), and United Nations (2019a).

As evidenced from Table 1, the lowest quantum and tempo of population ageing is observed among the more developed sub-regions of the world including European ones, Northern America and Australia/New Zealand. Northern and Southern Africa are also expected to age with a relatively low quantum and tempo but much later. Most of Asia and America are already ageing or expected to go through the process at a high quantum and tempo. The highest quantum and tempo are observed in Western Asia and in countries like Albania and Singapore. Afghanistan is estimated to age with the highest quantum and tempo during the second half of the 21st century.

The above culminates the research findings indicating that the process of population ageing has been accelerating in the less developed regions of the world. There exists a close relation of the timing and extent of age structure changes established during the process of demographic transition and observed further on in the context of population ageing.

Conclusion

The analysis of the quantum and tempo of population ageing by sub-regions and selected countries around the world has resulted in the following conclusions:

- The lowest quantum and tempo of population ageing was observed among European sub-regions, Northern America and Australia/New Zealand.
- Northern and Southern Africa are expected to experience similar quantum and tempo of population ageing towards the end of this century what was observed in Southern and Eastern Europe towards the end of the last century.
- The less developed American sub-regions along with most of Asia and part of Africa are ageing or estimated to age with a higher quantum and tempo (between 0.18–0.30 percentage points per year). While in Eastern Africa, Central and Southern Asia the proportion of older population should reach 14% of the total population only during the period 2050–2100.
- Western Asia along with selected countries including Albania, Afghanistan, Singapore and the United Arab Emirates are estimated to experience the highest magnitudes (very high quantum and tempo of more than 0.30 percentage points per year).

The aforementioned results denote that the processes of population ageing are accelerating further. The research findings also confirm the existence of close relation of the timing and extent of age structure changes in the context of population ageing. The quantum and tempo of ageing process tends to be higher and the duration shorter the more recent the demographic transition is.

"The future is upon us" (Schoeni & Ofstedal, 2010: 14). We have to act today, policy makers in the less developed countries have to make use of all the existing knowledge and experience, and develop measures at both national and local levels taking into consideration specific patterns of heterogeneity of ageing processes inherent to their population.

References

Balachandran, A., de Beer, J., James, K.S., van Wissen, L., & Janssen, F. (2019). Comparison of population aging in Europe and Asia using a time-consistent and comparative aging measure. *Journal of Ageing and Health,* 1–24.

Bongaarts, J., & Feeney, G. (1998). On the quantum and tempo of fertility. *Population and Development Review,* 24(2),271–291.

Bongaarts, J., & Feeney, G. (2003). Estimating mean lifetime. *Proceedings of the National Academy of Sciences,* 100(23), 13127–13133.

Burcin, B., Drbohlav, D., and Kucera, T. (2005). Czech Republic population prospects in the mirror of replacement migration concept. *Acta Universitatis Carolinae Geographica,* 1(2),47–67.

Caselli, G., and Vallin J. (1990). Mortality and population ageing. *European Journal of Population,* 6(1), 1–25.

Coale, A. J. (1956). The effects of changes in mortality and fertility on age composition. *Milbank Memorial Fund Quarterly,* 34(1),79–114.

Dyson, T. (2010). *Population and development: The demographic transition*. London: Zed Books.

European Union. (2018). The 2018 Ageing Report. [electronic resource]. Institutional Paper 079, May 2018. https://ec.europa.eu/info/publications/economic-and-financial-affairs-publications_en

Guillot, M. (2006). Tempo effects in mortality: An appraisal. *Demographic Research,* 14,1-26.

Harper, S. (2011). Demographic transition: Positioning the age-structural change perspective. *Population Ageing,* 4,119–120.

Kinsella, K. (2000). Demographic dimensions of global aging. *Journal of Family Issues,* 21, 541–558.

Kinsella, K., & Phillips, D.R. (2005). Global aging: The challenge of success. *Population Bulletin,* 60(1).

Kirk, D. (1996). Demographic transition theory. Population Studies, 50(3), 361-87.

Luy, M. (2010). Tempo effects and their relevance in demographic analysis. *Comparative Population Studies,* 35, 415–446.

Murphy, M. (2017). Demographic determinants of population aging in Europe since 1850. *Population and Development Review,* 43(2), 257–283.

National Institute of Aging and U.S. Department of State (2007). *Why population aging matters: A global perspective*. Washington, D.C.: National Institutes of Health.

Notestein, F.W. (1953). Economic problems of population change. *Proceedings of the Eighth International Conference of Agricultural Economics* (pp. 13–31). London: Oxford University Press.

Oeppen, J., & Vaupel, J. W. (2002). Demography – broken limits to life expectancy. *Science* 296,1029–1031.

Pavlik, Z. (1980). The theory of demographic revolution. *European Demographic Information Bulletin*, 11(4), 130–9.

Preston, S.H. & Stokes, A. (2012). Sources of population aging in more and less developed countries. *Population and Development Review*, 38(2), 221–36.

Preston, S.H., Himes, C., & Eggers, M. (1989). Demographic conditions responsible for population aging. *Demography,* 26(4), 691–704.

Reher, D.S. (2004). The demographic transition revisited as a global process. *Population, Space and Place,* 10, 19–41.

Ryder, N.B. (1964). The process of demographic translation. *Demography,* 1(1),74–82.

Sanderson, W. C., & Scherbov, S. (2005). Average remaining lifetimes can increase as human populations age. *Nature,* 435, 811–813.

Sanderson, W. C., & Scherbov, S. (2013). The characteristics approach to the measurement of population aging. *Population and Development Review,* 39, 673–685.

Schoeni, R.F., and Ofstedal, M.B. (2010). Key themes in research on the demography of aging. *Demography* 47(1),5–15.

Statistical Handbook of Japan. (2019). [electronic resource]. Statistics Bureau, Ministry of Internal Affairs and Communications, Japan. https://www.stat.go.jp/english/data/handbook/pdf/2019all.pdf#page=23

United Nations. (1973). The determinants and consequences of population trends. New summary of findings on interaction of demographic, economic and social factors. Volume 1. (Population Studies, No. 50; ST/SOA/SER.A/50). New York: United Nations.

United Nations. (1999). International Year of Older Persons 1999. Theme: Towards a society for all ages. [electronic resource]. Department of Economic and Social Affairs, Ageing. https://www.un.org/development/desa/ageing/resources/international-year-of-older-persons-1999.html

United Nations. (2002). Madrid International Plan of Action on Ageing. Report of the Second World Assembly on ageing, April 8–12, Madrid, Spain. https://www.un.org/esa/socdev/documents/ageing/MIPAA/political-declaration-en.pdf

United Nations. (2011). Current status of the social situation, well-Being, participation in development and rights of older persons worldwide. [electronic resource]. New York: Department of Economic and Social Affairs, Population Division. http://www.un.org/esa/socdev/ageing/documents/publications/current-status-older-persons.pdf

United Nations. (2013). World Population Ageing 2013. New York: Department of Economic and Social Affairs, Population Division.

United Nations. (2019a). World Population Prospects: The 2019 Revision. [electronic resource]. New York: Department of Economic and Social Affairs, Population Division.
https://population.un.org/wpp/

United Nations. (2019b). International Day of Older Persons. [electronic resource]. Department of Economic and Social Affairs, Ageing.
https://www.un.org/development/desa/ageing/international-day-of-older-persons-homepage.html

United Nations. (2020). World Population Ageing 2019. New York: Department of Economic and Social Affairs, Population Division.

United Nations Economic Commission for Europe. (UNECE) (2020). Review and appraisal. [electronic resource]. United Nations Economic Commission for Europe.
https://unece.org/review-and-appraisal

Vallin, J. (2002). The end of the demographic transition: Relief or concern? *Population and Development Review*, 28(1),105–120.

van Imhoff, E., & Keilman, N. (2000). On the quantum and tempo of fertility [Comment]. *Population and Development Review,* 26(3), 549–553.

Wilmoth, J. (2015). Global trends in fertility and population ageing, John Wilmoth, Director, Population Division. Briefing for Member States, on Policy Responses to Low Fertility 3 November 2015.
http://www.un.org/en/development/desa/population/events/pdf/expert/24/Presentations/John_Wilmoth_MSBriefing03Nov2015.pdf