# A Study of Temporary Life Expectancy and its Related Measure Under Dynamic Approach

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**Abstract**

The period life table assumes that an individual at any particular age of his/her life will be subject to the same mortality pattern throughout their lives. From statistical point of view, human life is subject to change. Here comes the concept of dynamic life table (Denton and Spencer, 2011) which takes into account the continuous changes in mortality that period life expectancy fails to conquer. Hence, the paper mainly focuses on the dynamic extension of period life table and how it can impact the values of temporary life expectancy (TLE) between any two age ranges for the selected 199 countries of the world. Further, the study attempted to develop a formula to estimate the annual relative change (ARC) index in TLE under dynamic scenario over the past 10 years (2000-2005 to 2010-2015) and 25 years (1985-1990 to 2010-2015) respectively. Our analysis reveals that the values of TLE and the ARC indices in TLE have increased under the dynamic procedure as compared to the usual one during both the 10 and 25 years interval in all the countries (except few), in all the age ranges viz. 0-5, 5-15, 15-60, 60-75 and 75+, which indicates steeper mortality decline throughout the period.

**Key words:** Mortality; Life Table; Temporary Dynamic Life Expectancy; Annual Relative Change Index.

## Background

Risks to life are close to the individual at all ages; no age is or can be entirely free from mortality (UN, 1955). Ideally, since mortality risks are much higher for old people than for young people, same mortality risks will give a higher crude death rate in a population where the proportion of old people is higher than in a population where such proportion is lower (Meslé et al., 2010). One of the convenient and most frequently used summary indicator for analyzing change in mortality is the life expectancy at birth. Life expectancy at birth reflects the overall mortality level of a population. It summarizes the mortality pattern that prevails across all age groups - children and adolescents, adults and the elderly (WHO, 2014). Since the World War II, all regions of the world have seen substantial increases in life expectancy at birth. The world as a whole gained 23.7 years of life expectancy since the early 1950s, reaching a level of 70.5 years in the years from 2010 to 2015 (World Mortality Report 2015). This rise in human life expectancy over the past two centuries is a remarkable accomplishment of modern civilization (Aburto et al., 2020).

Although, longevity has improved in virtually all of the world's populations, progress in some regions has outpaced that in others which, in turn, mask large differentials among the regions. This has been clearly revealed in the literature wherein in most of the developed countries and in a number of developing countries, the demographic transition which was complete by the turn of the twentieth century, gains in survival at older ages have begun at a steady pace whereas many less developed countries, especially Sub Saharan

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Africa, are still in the second stage of demographic transition, with reduction in mortality among infants and young adults and will enter the final stage in the next few decades (Census of India, 2011 & UNFPA; National Research Council 2000).

When life expectancy improves, it is nearly always the result of progress in survival among both children and adults, but the relative contribution of the different age groups changes according to the stage of demographic transition (Sharma et al. 2017).The world demographic data clearly demonstrates this fact where in regions that had low life expectancy at birth in 1950-1955—including Africa, developing Oceania, Asia, and Latin America and the Caribbean—the majority of gains in survival to 2005-2010 were achieved through reductions in mortality below the age of 15, whereas in the developed regions, survival above age 60 accounted for a far greater proportion of overall gains in life expectancy during the same period (UN 2012).

Moreover, although, it is well known that life expectancy across the world has increased substantively as a result of successive reduction in child mortality, however, it was not only children that benefited from this progress, but life expectancy increased for people at all ages (Roser et al. 2013). In other words, the age at which people die has changed significantly since 1990, with fewer people dying at a young age. For instance, in 2017, there were 56 million deaths globally; nearly half of these (49%) were people who were 70 years or older; 27% were between 50 and 69 years old; 14% were between 15 and 49; only 1% were older than 5 and younger than 14; and almost 10% were children under the age of 5 (GBD 2017).This has ultimately resulted in the increase in the number of older persons in the world in the recent years, where among the 7.3 billion people worldwide in 2015, an estimated 617.1 million are aged 65 and older (Wan He et al., 2016).

Although, of all the summary measures that can be derived from a life table, the expectation of life (or life expectancy) is perhaps the most well-known, widely-used, widely-cited and widely-studied statistic (Carlson, 2006), however, the measurement and interpretation of life expectancy changes are affected by a problem of relative magnitude. Moreover, a major lacunae of life expectancy indicator is that it measures the mortality level for an open age interval x and above and therefore it is often limited to the problems of data reliability in older age groups and the restriction on limits of human life span (Arriaga, 1984). Both these problems can be avoided by the use of temporary life expectancies (life expectancies between two specific ages) and indices based on the comparison of temporary life expectancies. While life expectancy at birth depends on mortality rates over the whole range of ages, temporary life expectancy depends only on mortality rates between two exact ages (Saikia et al. 2011). The term 'temporary life expectancy' was first introduced by E. Arriaga (1984) and thereby it has been used widely across the literature (Arriaga, 1984; Pollard, 1988; Saikia et al., 2011; Thomas et al., 2014; Cervantes et al., 2018). However, all these previous studies have tended to explore the growth mechanism of life expectancy across various age groups under the assumption that the mortality rates remain the same throughout the years. Since mortality rates are expected to change over time among all ages in all the regions of the world, as such, the temporary life expectancies under dynamic consideration will condense information on the changing mortality

schedule between any two ages considerably (Sharma et al., 2017). Moreover, while the absolute change of temporary life expectancies will give the increase or decrease of years of life between two particular ages, it should not be used for analyzing the pace of mortality change (Arriaga, 1984). As has been suggested (Arriaga, 1971), the pace of mortality change during a period of time should be treated as a relative measure, i.e., the observed change in temporary life expectancies in relation to the possible maximum change. As such, we use the concept of annual relative change (ARC) Index in TLE, which represents the percentage change in two mortality measures in their observed reduction in deaths in relation to the total possible reduction. In other words, it shows the change in number of years lived between two periods considering the maximum possibility of reduction in that age group (Arriaga, 1984; Thomas et al., 2014). With this purpose, we extend the formula for temporary life expectancy (TLE) and annual relative change (ARC) index in TLE to suit the dynamic life table and shall apply it to the selected 199 countries of the world for both the sexes for the period 2010-2015 based on the rates of change of probabilities of death over the previous past 10 and 25 years (i.e., 2000-2005 and 1985-1990 respectively. However, in the present paper the 'dynamic life table' applies only if the observed mortality rates of the period life tables continue to change and should not be used for forecasting (Denton & Spencer, 2011; Sharma et al., 2017).

**Objectives**

In accordance with the purpose of the study, we singled out the following objective:

To estimate dynamic temporary expectation of life between any two ages for both sexes for the selected 199 countries of the world for the period 2010-2015 based on the rates of change of probabilities of death over the previous past 10 and 25 years (i.e., 2000-2005, 1985-1990 respectively) and to estimate the annual relative change (ARC) Index in TLE's under dynamic scenario over the past 10 years (2000-2005 to 2010-2015) and 25 years (1985-1990 to 2010-2015) respectively. For the purpose of analysis, the study classifies the male and female population into four major groups as infancy and childhood phase (aged 0_5 years), adolescence phase (aged 5_15 years), adulthood phase (aged 15_60 years) and old age phase (aged _60 years and above). Further, considering the vulnerability of diseases in the old age group, we have sub-divided old age group into older age group (aged 60_75 and the oldest age group (aged 75+) for both males and females respectively.

**Data**

The data on demographic trends used in the present study were taken from the 2017 Revision of the World Population Prospects. The 2017 Revision of World Population Prospects is the twenty-fifth round of official of the United Nations population estimates and projections that have been prepared by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. It provides a comprehensive set of demographic data and indicators to assess population trends at the global, regional and national levels and to calculate many other key indicators commonly used by the United Nations system. In the 2017 Revision of the World Population Prospects, standard demographic techniques were used to estimate the population by age and sex, as well as trends in total fertility, life expectancy at birth, infant mortality and international migration for the years 1950 through 2017,

from data available from censuses and post-enumeration surveys; demographic and health surveys; population and vital registration systems; scientific reports and data collections; and from data and estimates provided by international agencies. The resulting estimates provided the basis from which the population projections follow. The World Population Prospects 2017 was released in mid-2017 which includes abridged life tables by region, sub region and country for five-year periods 1950-1955,……,2095-2100, for age groups 0, 1, 5, 10,….., 100+ by sex.

Thus, in the present study, to estimate dynamic temporary life expectancy, we need to construct dynamic life tables. For this, the abridged life tables for the period 2010-2015, 2000-2005 and 1985-1990 are taken from the WPP 2017 for the selected countries of the world. Taking the period 2010-2015 as the reference period, the dynamic life tables for the different periods over the previous 10 (2000-2005) and 25 (1985-1990) years are constructed in order to bring out the implications for maintaining the rates of change of probabilities of death for the reference period (which has already being communicated elsewhere). After that, the temporary life expectancy (TLE) and annual relative change (ARC) Index in TLE are constructed accordingly for the selected 199 countries of the world for both the sexes under dynamic approach.

**Methodology**

*Temporary expectation of life (TLE) and Annual Relative Change (ARC) Index under dynamic consideration*

Temporary expectation of life is an index which not only helps in understanding variations in age patterns, but also facilitates comparison of different reasons for mortality (Kohli, 1977). Factors which affect mortality are associated differently with the different phases of life, and this division is useful for analytical purposes. The entire life span can be divided as infancy and childhood phase (0-5 years), adolescence phase (5-15 years), adulthood phase (15-60) years and lastly, the old age group (60+ years) which is further subdivided into older age group (aged 60_75) and the oldest age group (aged 75+). The temporary expectation of life between the exact ages *x and x+i* is given by

$$_i e_x = \frac{T_x - T_{x+i}}{l_x} \quad \text{(Arriaga, 1984)}$$

The dynamic temporary expectation of life between any two ages is then calculated using the same procedures as mentioned above and is given by:

$$_i e_{xy} = \frac{T_{xy} - T_{x,y+i}}{l_{xy}} \qquad \text{(Sharma et al. 2017)}$$

where $_i e_{xy}$ is the average number of years that the survivors of $l_{xx}$ cohort, alive at age $y$ will live from age $y$ *to* $y+i$ and $T_{xy}$ is the number of person years yet to be lived by $l_{xx}$ cohort.

The Annual Relative Change (ARC) is given by:

$$i^{ARC_x^n} = [1 - (1 - i^{RC_x^n})^{\frac{1}{n}}] .100$$

where $i^{ARC_x^n}$ represents index of ARC in TLE; n is the number of years, and $i^{RC_x^n}$ is the observed change in TLE in relation to the maximum possible change, where $i^{RC_x^n}$ can be calculated as,

$$i^{RC_x^n} = \frac{i^{e_x^{t+n}} - i^{e_x^t}}{i - i^{e_x^t}}$$

where $i^{e_x^{t+n}} - i^{e_x^t}$ is the absolute change of TLE of years of life between two particular ages; i is the maximum possible TLE between the age intervals and t is the initial year of the

observation period of n years.

Using the same procedure as above, the ARC in TLE under dynamic consideration can be calculated as:

$$i^{ARC_{xy}^{n}} = \left[1 - \left(1 - i^{RC_{xy}^{n}}\right)^{\frac{1}{n}}\right].100$$

where $i^{ARC_{xy}^{n}}$ represents Index of ARC in dynamic TLE and $i^{RC_{xy}^{n}}$ can be calculated as,

$$i^{RC_{xy}^{n}} = \frac{i^{e_{xy}^{t+n}} - i^{e_{x}^{t}}}{i - i^{e_{x}^{t}}} \text{ where } i^{e_{xy}^{t+n}} - i^{e_{x}^{t}}$$

is the absolute change of dynamic TLE of years of life between two particular ages; $i$ is the maximum possible TLE between the age intervals.

**Results and Discussion**

The change in period as well as dynamic TLE is found to vary for different phases of life. For the 199 countries under study we have examined the differences for all the age groups to maximum possible years, which is 5 years for the infancy and childhood period, 10 years for the adolescence period, 45 years for the adulthood period and lastly 40 years for the older population which is again sub divided into 15 years and 25 years viz. older and oldest age group. To study the distributions of observed as well as dynamic TLE's in the various age ranges for all the selected 199 countries under study, we have summarized and visualized all the data in the ArcMap 10.2.1 version. ArcGIS is a geographical information system (GIS) software that allows handling and analyzing geographic information by visualizing geographical statistics through layer building maps. In the present study, the TLE data has been arranged in the ArcGIS database and the countries shape files have been utilized from DIVAGIS platform (Open source). Six output maps have been generated accordingly in each of the age ranges depicting the TLE's under both period and dynamic state for both the 10- and 25-years interval which are presented below in Figure 1.1 (15-60 age range), Figure 1.2 (60-75 age range) and Figure 1.3 (75+ age range) for males and females separately. Our analysis records most of the countries under study (except few) have attained almost maximum TLE in the age ranges viz. 0-5 and 5-15, for both the sexes, under both period and dynamic consideration with approximately 5 years and 10 years respectively during both the intervals. As such we have confined our study in the age ranges 15-60, 60-75 and 75+ only as the effects of mortality are mostly seen in these age ranges.

The colours in the maps portrays the TLE's of the countries of the world under both dynamic and usual consideration. For the adult age group 15-60, the pink colour represents TLE of the countries below 40 years, green colour stands for the TLE ranging from 40-42.99 years and yellow colour displays the TLE under the range 43 and above. Similarly, for the older age groups viz. 60-75, the pink colour denotes the TLE of the countries below 10 years, green colour for 10-11.99 years, yellow for 12-13.99 years and blue colour for the range 14 and above. Finally, for the oldest age group 75+, the pink, green, yellow and blue colour represents TLE of the countries below 6 years, 6-7.99 years, 8-8.99 years and 9 years and above respectively. Figure 1.1 below depict that under periodic scenario, the large portion of the maps are painted in pink and green colour (especially for males), which denotes lower values of TLE in the age group 15-60. On the other hand, under dynamic consideration, the maximum portion of the maps are coloured in yellow which indicates higher

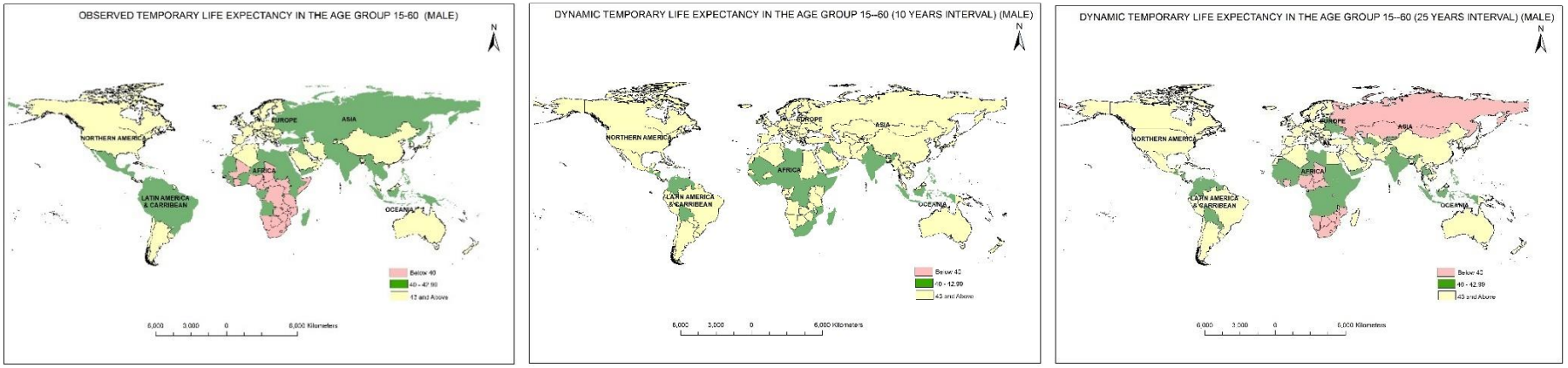
values of TLE in the corresponding age group among the selected countries of the world. A similar result has been observed for the other two age groups viz. 60-75 and 75+ which are illustrated in figure 1.2 and 1.3 below wherein under usual consideration, the maximum portion of the maps are painted in green as well as yellow colour, denoting lower values of TLE whereas under dynamic scenario, the larger portion of the maps are coloured in blue which indicates higher values of TLE. Thus, the figures below clearly illustrate the fact that the TLE's of both males and females of the selected 199 countries under study (except few) have increased under dynamic procedure compared to the usual procedure which is a clear indication of sharp mortality reduction in all the age groups over both the previous 10 and 25 years interval. Various social and economic development as reflected in standards of nutrition, better water supplies and the growth of public sanitation, higher living standards and educational standards, technological advances in the prevention and effective control of dangerous infectious and parasitic diseases and better medical facilities, that have relatively reduced the costs of good health, might be the important factors that have contributed to this improvement in mortality (Smith, 1967; Preston, 1980; Neupert, 1995). Moreover, reviewing mortality by sex, it can be stated that females tends to live longer than males and our study clearly supports this phenomenon wherein both under periodic and dynamic consideration, the pink and green colour in the maps which portrays lower life expectancies are found to be less in case of females compared to males in all the three age groups.

Although, mortality has declined dramatically over the last few decades, however, the constancy of mortality reductions masks significant heterogeneity by age across all regions and countries. This can be clearly observed from the figures above wherein during the 25 years interval (especially for males), quite a large portion of the maps are sketched in pink and green colour which indicates that the TLE's of some of the countries have remained either stagnant or have declined in all the three age groups. To discuss this scenario in details, we have presented the top five and bottom five countries in each of the continent (due to limitation of space) with the highest and lowest values of dynamic TLE over both the intervals in the selected age ranges for both the sexes in Table 1.1 to 1.6 below.

Table 1.1 reveals that in Asia, the lower performance of TLE during the 25 years interval in both the adult and the old age groups are mostly observed among the Islamic countries which includes Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Pakistan, Indonesia, Armenia, Azerbaijan, Georgia, Iraq and Yemen. This may be clearly justifiable by the fact that, although globally considerable progress has been made in reducing maternal mortality, still more than 99% of maternal deaths occur in the developing countries and the overall progress of this reduction was found to be much slower in the Islamic countries (COMCEC) 2019). Further, in the 1990s, Central Asia experienced many hardships of economic transition such as skyrocketing inflation, partial de-industrialization and the collapse of Soviet-type welfare systems (Batsaikhan et al., 2017) due to which premature mortality and the prevelance of CVD risk factors such as hypertension, diabetes, tobacco use, and alcohol use are found to be high among the Central Asian

**MALES**

Observed TLE | Dynamic TLE (10 years) | Dynamic TLE (25 years)




**FEMALES**

Observed TLE | Dynamic TLE (10 years) | Dynamic TLE (25 years)

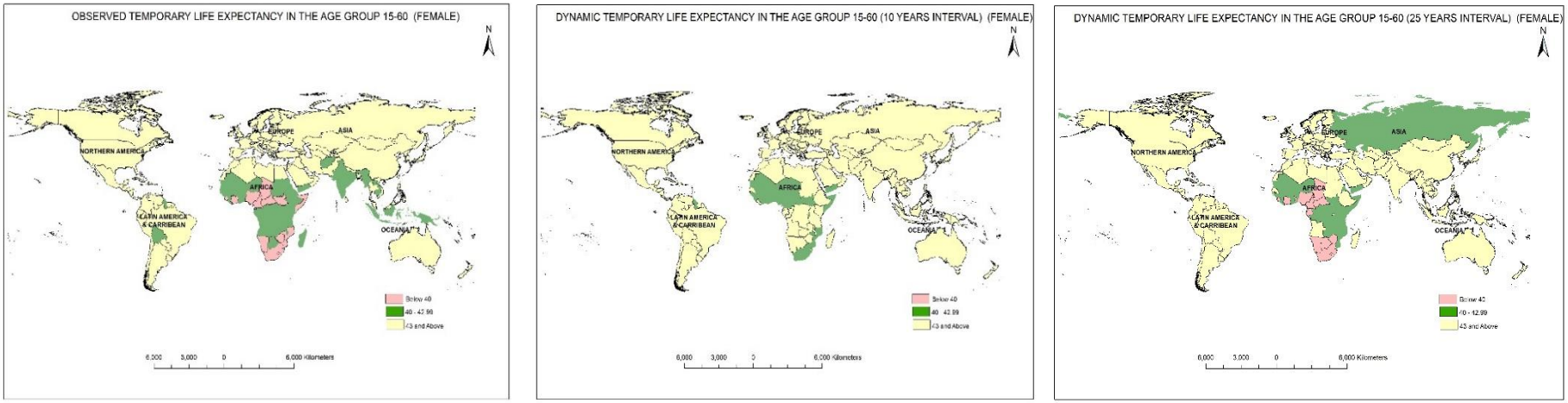
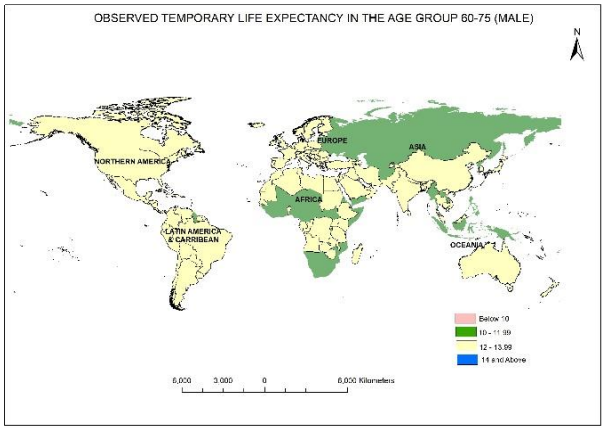
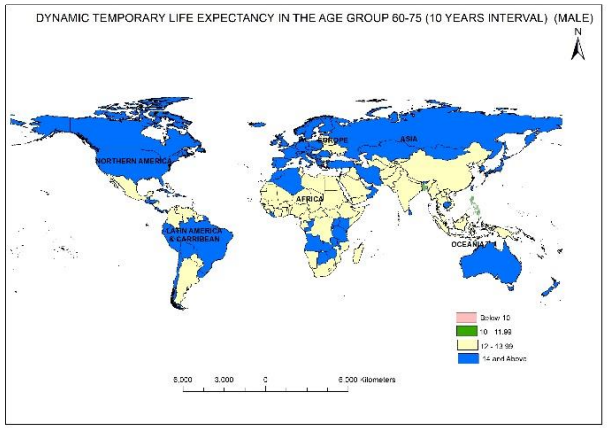


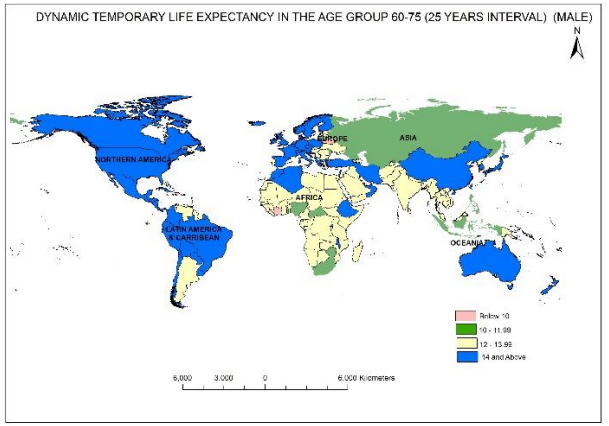

**Figure 1.1** Temporary Life Expectancy for the age group (15- 60) under both Observed and Dynamic Consideration for both sexes

**MALES**

Observed TLE | Dynamic TLE (10 years) | Dynamic TLE (25 years)

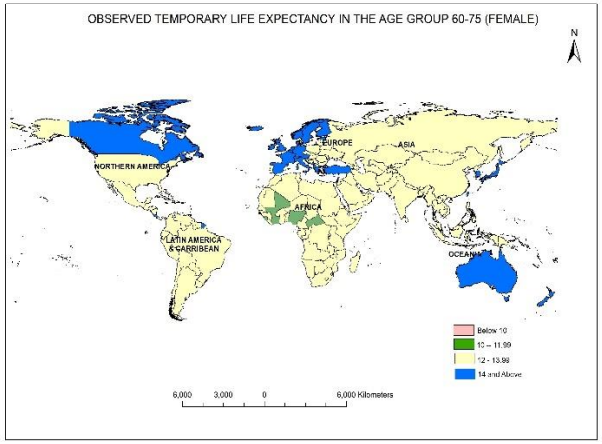


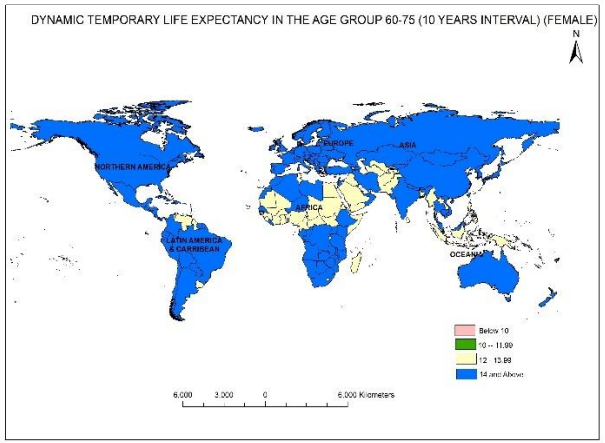




**FEMALES**

Observed TLE | Dynamic TLE (10 years) | Dynamic TLE (25 years)



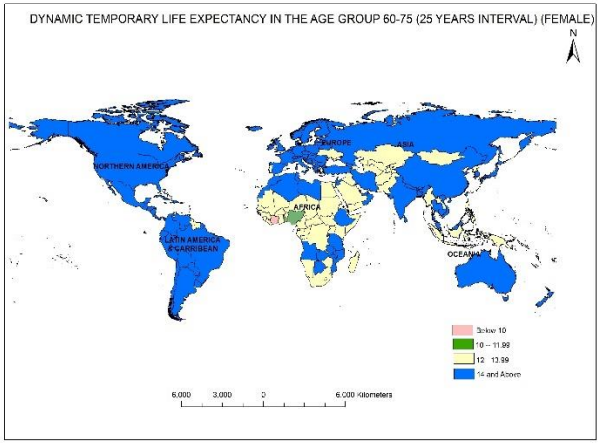
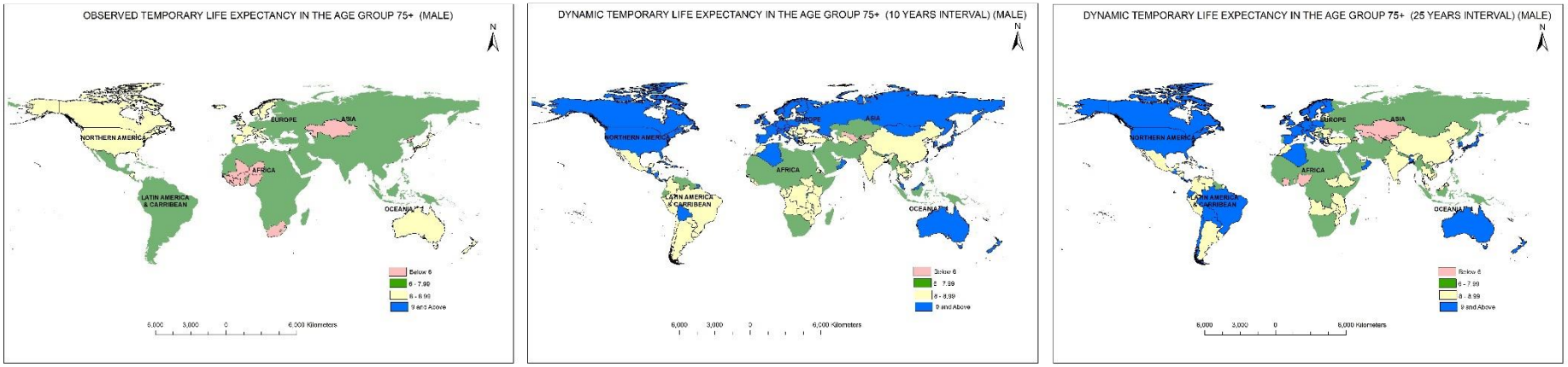




**Figure 1.2** Temporary Life Expectancy for the age group (60-75) under both Observed and Dynamic Consideration for both sexes

**MALES**

Observed TLE | Dynamic TLE (10 years) | Dynamic TLE (25 years)




**FEMALES**

Observed TLE | Dynamic TLE (10 years) | Dynamic TLE (25 years)

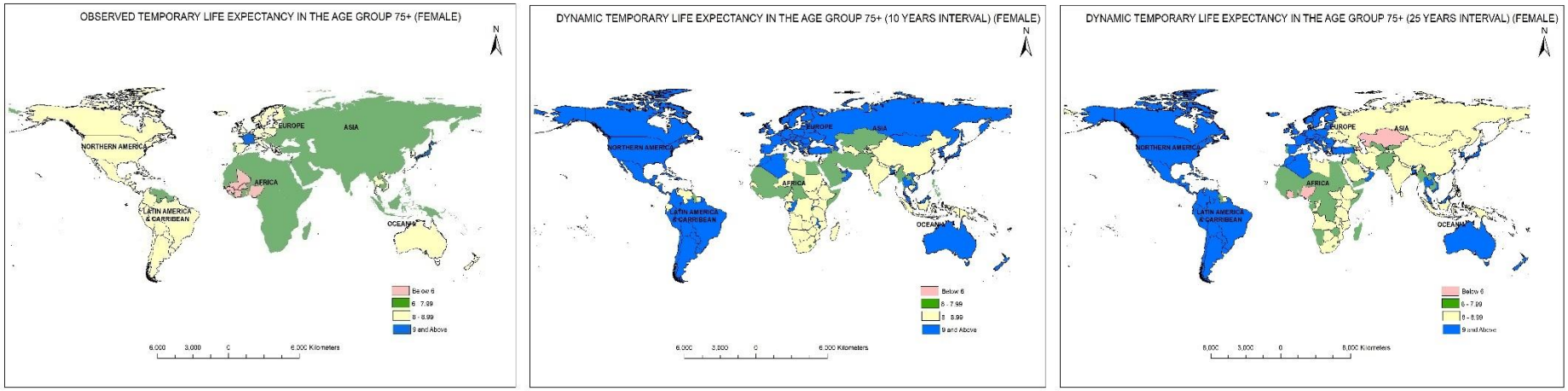



**Figure 1.3** Temporary Life Expectancy for the age group (75+) under both Observed and Dynamic Consideration for both sexes

Population (Aringazina et al, 2018), which may be attributed as one of the main reason for higher deaths among the adult and old population in these countries. A similar pattern has been observed in the Caucasian countries viz. Armenia, Azerbaijan and Georgia. With the collapse of the Soviet Union, these countries have experienced remarkable migration flows, political conflicts, and deterioration of civil registration systems which ultimately led to worsening health levels in these countries (Duthe et al., 2010; Health Information Unit, WHO Regional Office for Europe; 2001). Meanwhile, in Georgia, the values of TLE are found to be much low with even negative differences between the observed and dynamic TLE's during both the 10- and 25-years interval which indicates sharp mortality increase, particularly adult males, among the Georgian population. One of the possible reasons for this may be that due to non-existent or potentially flawed data and a combination of structural economic changes and political and social instability during the 1990s, the country has not experienced any progress in adult mortality, especially males, and the mortality levels are found to be similar to those observed in the late 1970s, with a worrisome increase being detected among the males (Kellersmann et al., 2019); Duthe et. al, 2017). Some other Asian countries viz. Mongolia, Democratic Republic of Korea (North Korea) and Thailand have also experienced lower performance of Dynamic TLE over the 25 years interval. The main reason behind this decline might be due to deterioration of the North Korean economy as a result of disastrous combination of flooding in 1995-1996, and drought in 1997 (Zhao and Kinfu, 2005). Similarly, due to severe economic downturn (1990-1994) in Mongolia, adult mortality (especially males) has increased in the region with cancer, cardiovascular disease and accidents acting as the biggest contributors to this rise (World Bank; 2007). In addition to this, adult mortality, especially males, in Thailand, seems to increase during the 25 years interval mainly due to the traffic road accident between the late 1980s and early 1990s and the prevelance of HIV/AIDS epidemic after 1984(Carmichael; 2011).

Among the African countries, most of the countries have witnessed either lower or negative differences between dynamic and observed TLE mostly in the adult age group which may be attributable to slower improvements or rather increase in adult mortality in these countries during the last 25 years. This includes mainly the South African countries viz. Lesotho, Swaziland, South Africa, Botswana, Namibia and a few other countries viz. Zimbabwe, Central African Republic, Côte d'Ivoire, Cameroon, Togo and Chad (Please refer table 1.2 below). The possible reason for this increasing mortality in these countries might be the spread of HIV AIDS during the 1990s, especially in the South African countries, where the mortality rates exceeded those in countries that experienced episodes of civil war (Walque et al., 2011). Further, the impact of the epidemic on mortality may be indicated by the observation that the mortality of women aged 25–29 years was 3.5 times higher in 1999/2000 than in 1985, while that of men aged 30–39 doubled in the same period (Bradshaw and Timaeus, 2006; Laura B. Shrestha; 2000; Hosegood et al., 2004). It may however be noted that among all the countries under study, almost 90% countries from Africa exhibits highest differences between the observed and dynamic TLE's in the age group 15-60 during the 10 year interval which means that adult mortality have declined much more rapidly in the African region compared to the other

regions in the recent decade. According to the World Health Statistics 2016 report, this increase was mainly by improvements in child survival, progress in malaria control and expanded access to antiretroviral therapy (ART) for treatment of HIV (Kharsany et al., 2016).

Table 1.3 below reveals that although the European countries records the highest life expectancy among the countries of the world, however, some countries from Eastern Europe mainly Russian Federation, Belarus, Ukraine, Republic of Moldova and the Baltic states viz. Lithuania and Latvia exhibit lower values of dynamic TLE's than the usual TLE's during the 25 years period in all the three age ranges as compared to the other European countries. Moreover, in most of these countries, the differences between the observed and the dynamic TLE's during the 25 years interval are either negative or are much lower in comparison to the other European countries which indicates sharp mortality increase or rather the intensity of mortality stagnated during the period 1985-1990 to 2000-2005. One of the main reason for this increasing mortality might be the dissolution of the Soviet union in 1989, accompanied by crises as well as political and social transformation, as a result of which most of these countries experienced a demographic disaster in the form of sharply rising death rates (Brainerd et al., 2005; GBD 2016).

Furthermore, although most of the Latin American countries have experienced an accelerated decrease in mortality since the mid-1950s, translating into continuous improvements in life expectancy (Calazans and Quieroz; 2020), however, over the 25 years interval, the values of dynamic as well as observed TLE in all the three age groups, especially adult age, are found to be much lower in most of the developing countries of this region as compared to the other developing regions. This mainly includes Venezuela, Trinidad and Tobago, Jamaica, Suriname, Costa Rica, Ecuador, Saint Vincent and the Grenadines, Paraguay, Haiti, Bahamas, Colombia, Saint Lucia and Guyana (please refer table 1.4 below). Increase in violence-related deaths, especially homicide, among young adult males and high maternal mortality may be attributed as one of the primary reason for the lower values of TLE in these countries (Health Equity Report 2016; Imbusch et al., 2011). Moreover, according to the report 'Trends in Maternal Mortality Estimates 1990-2013', it has been observed that although globally, maternal deaths have declined by 45% since 1990, the Latin America and the Caribbean region experienced the smallest annual decline in maternal mortality of any region between 1990 and 2013, at 1.1%.

Among the other two regions viz. Oceania and Northern America, table 1.5 and 1.6 below display that the lower performance in usual as well as dynamic TLE are observed mostly in Fiji, Micronesia (Fed. States of), Tonga and Kiribati. Further, the values of dynamic as well as observed TLE is found to be quite low in USA in the age group 15-60 compared to the other developed countries of the world. Recent evidence indicates that Americans usually experience higher levels of disease and disability at below age 50 than do their counterparts in other industrialized nations and the major causes of death responsible for this below-fifty trends are unintentional injuries, including drug overdose; noncommunicable diseases; perinatal conditions such as pregnancy complications and birth trauma; and homicide (Jessica Y. Ho, 2013; Avendano et al., 2014).

**Table 1.1** Top five and bottom five countries with the highest and lowest Temporary Dynamic Life expectancy for the period 2010-15 in the selected age ranges for both the sexes, ASIA

| Age Range | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | 10 years | | 25 years | | 10 years | | 25 years | |
| | Highest | Lowest | Highest | Lowest | Highest | Lowest | Highest | Lowest |
| 15-60 | Lebanon (44.8) | Georgia (38.6) | Maldives (44.9) | Mongolia (39.3) | Maldives (45.0) | Yemen (42.9) | Maldives (45.0) | Kazakhstan (42.5) |
| | Singapore (44.8) | Philippines (41.9) | Lebanon (44.8) | Kazakhstan (39.6) | Iran (44.9) | Iraq (43.2) | China, Macao SAR (44.9) | Yemen (42.8) |
| | Maldives (44.8) | Iraq (42.3) | Republic of Korea (44.8) | Thailand (41.4) | China, Macao SAR (44.9) | Georgia (43.5) | Iran (44.9) | Indonesia (43.6) |
| | Iran (44.7) | Srilanka (42.3) | Iran (44.8) | Kyrgyzstan (41.9) | Cyprus (44.9) | Indonesia (43.6) | Cyprus (44.9) | Afghanistan (43.7) |
| | Republic of Korea (44.7) | Yemen (42.5) | China, Macao SAR (44.7) | Georgia (42.0) | Timor-Leste (44.8) | Afghanistan (43.7) | United Arab Emirates (44.9) | Iraq (43.7) |
| 60-75 | Republic of Korea (14.9) | Georgia (7.9) | Republic of Korea (14.9) | Kazakhstan (10.7) | Republic of Korea (15.0) | Turkmenistan (12.5) | Republic of Korea (15.0) | Uzbekistan (12.5) |
| | Singapore (14.9) | Qatar (11.4) | Singapore (14.8) | Georgia (11.3) | Singapore (14.9) | Iraq (13.0) | China, Macao SAR (14.9) | Turkmenistan (12.5) |
| | Lebanon (14.7) | Philippines (11.7) | China, Hong Kong SAR (14.7) | Mongolia (11.4) | China, Macao SAR (14.9) | Uzbekistan (13.1) | China, Hong Kong SAR (14.9) | Tajikistan (12.8) |
| | China, Macao SAR (14.7) | Bangladesh (11.9) | Israel (14.7) | Uzbekistan (11.4) | Lebanon (14.9) | Tajikistan (13.1) | Singapore (14.9) | Pakistan (13.0) |
| | Israel (14.7) | Iraq (12.1) | China, Macao SAR (14.7) | Turkmenistan (11.5) | China, Hong Kong SAR (14.9) | Armenia (13.1) | Israel (14.9) | Yemen (13.1) |
| 75+ | Singapore (9.8) | Georgia (5.3) | Republic of Korea (9.6) | Kazakhstan (3.7) | Republic of Korea (10.0) | Georgia (5.9) | Japan (9.9) | Kazakhstan (4.6) |
| | Republic of Korea (9.7) | Kyrgyzstan (5.7) | China, Taiwan Province of China (9.5) | Kyrgyzstan (5.3) | Singapore (9.9) | Uzbekistan (6.1) | China, Hong Kong SAR (9.9) | Azerbaijan (5.9) |
| | China, Hong Kong SAR (9.5) | Uzbekistan (5.8) | China, Hong Kong SAR (9.5) | Uzbekistan (5.6) | China, Macao SAR (9.9) | Kazakhstan (6.5) | Republic of Korea (9.9) | Uzbekistan (6.7) |
| | Israel (9.5) | Iran (6.3) | Bangladesh (9.5) | Azerbaijan (5.6) | China, Hong Kong SAR (9.8) | Pakistan (6.7) | China, Macao SAR (9.8) | Kyrgyzstan (6.7) |
| | Lebanon (9.4) | Iraq (6.3) | Singapore (9.5) | Georgia (6.2) | Japan (9.8) | Iraq (6.9) | China, Taiwan Province of China (9.8) | Yemen (7.0) |

**Table 1.2** Top five and bottom five countries with the highest and lowest Temporary Dynamic Life expectancy for the period 2010-15 in the selected age ranges for both the sexes, AFRICA

| Age Range | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | 10 years | | 25 years | | 10 years | | 25 years | |
| | Highest | Lowest | Highest | Lowest | Highest | Lowest | Highest | Lowest |
| 15-60 | Morocco (44.9) | Equatorial Guinea (38.5) | Morocco (44.8) | Lesotho (20.3) | Morocco (44.8) | Equatorial Guinea (39.5) | Réunion (44.8) | Lesotho (22.1) |
| | Malawi (44.5) | Guinea-Bissau (40.0) | Tunisia (44.6) | Swaziland (21.6) | Mayotte (44.8) | Nigeria (40.5) | Tunisia (44.8) | Swaziland (27.1) |
| | Algeria (44.4) | Lesotho (40.1) | Algeria (44.4) | South Africa (30.2) | Réunion (44.8) | South Sudan (40.8) | Morocco (44.8) | Botswana (28.2) |
| | Rwanda (44.4) | Côte d'Ivoire (40.1) | Mayotte (44.3) | Botswana (32.2) | Rwanda (44.8) | Côte d'Ivoire (40.8) | Mauritius (44.6) | Zimbabwe (28.4) |
| | Tunisia (44.4) | Chad (40.1) | Réunion (44.3) | Namibia (32.4) | Botswana (44.7) | Chad (40.9) | Mayotte (44.6) | South Africa (29.3) |
| 60-75 | Morocco (14.9) | Guinea-Bissau (11.7) | Morocco (14.7) | Côte d'Ivoire (9.3) | Morocco (14.9) | Egypt (12.8) | Mauritius (14.9) | Côte d'Ivoire (8.4) |
| | Algeria (14.7) | Seychelles (12.1) | Algeria (14.6) | Swaziland (10.4) | Malawi (14.9) | Nigeria (13.1) | Mayotte (14.9) | Togo (11.4) |
| | Rwanda (14.6) | South Africa (12.4) | Mayotte (14.5) | Lesotho (10.4) | Rwanda (14.8) | Chad (13.1) | Morocco (14.8) | Nigeria (11.5) |
| | Mayotte (14.5) | Ethiopia (12.4) | Réunion (14.5) | Central African Republic (11.6) | Algeria (14.8) | Somalia (13.1) | Réunion (14.7) | Central African Republic (12.0) |
| | Réunion (14.5) | Gambia (12.5) | Rwanda (14.1) | Togo (11.6) | Mayotte (14.7) | Côte d'Ivoire (13.2) | Algeria (14.7) | Lesotho (12.0) |
| 75+ | Algeria (9.5) | Guinea-Bissau (5.7) | Algeria (9.5) | Côte d'Ivoire (4.1) | Réunion (9.5) | Egypt (6.8) | Mauritius (9.9) | Côte d'Ivoire (3.5) |
| | Mayotte (9.3) | Gambia (6.4) | Mauritius (9.4) | Nigeria (5.6) | Mayotte (9.5) | Nigeria (6.9) | Mayotte (9.9) | Togo (5.3) |
| | Réunion (9.3) | Nigeria (6.6) | Mayotte (9.3) | Togo (5.7) | Algeria (9.5) | Mauritania (6.9) | Réunion (9.5) | Nigeria (5.4) |
| | Rwanda (9.1) | Libya (6.7) | Réunion (9.3) | Guinea (6.2) | Mauritius (9.4) | Gambia (7.0) | Algeria (9.5) | Guinea (6.1) |
| | Congo (8.9) | Ethiopia (6.7) | Ethiopia (8.5) | Gambia (6.4) | Rwanda (9.3) | Guinea-Bissau (7.1) | Morocco (9.0) | Burkina Faso (6.4) |

**Table 1.3** Top five and bottom five countries with the highest and lowest Temporary Dynamic Life expectancy for the period 2010-15 in the selected age ranges for both the sexes, EUROPE

| Age Range | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | 10 years | | 25 years | | 10 years | | 25 years | |
| | Highest | Lowest | Highest | Lowest | Highest | Lowest | Highest | Lowest |
| 15-60 | Channel Islands (44.8) | Lithuania (43.2) | Channel Islands (44.8) | Russian Federation (38.6) | Switzerland (45.0) | Russian Federation (44.2) | Slovenia (44.9) | Russian Federation (42.7) |
| | Luxembourg (44.8) | Russian Federation (43.6) | Luxembourg (44.7) | Belarus (40.6) | Slovenia (44.9) | Lithuania (44.3) | Malta (44.8) | Ukraine (43.3) |
| | Netherlands (44.8) | Belarus (43.8) | Netherlands (44.7) | Lithuania (41.7) | Luxembourg (44.9) | Ukraine (44.3) | Italy (44.8) | Belarus (43.8) |
| | Spain (44.8) | Ukraine (43.8) | Spain (44.7) | Ukraine (42.6) | Denmark (44.9) | Bulgaria (44.4) | Spain (44.8) | Lithuania (44.1) |
| | Slovenia (44.8) | Iceland (43.9) | Slovenia (44.7) | Latvia (42.8) | Netherlands (44.9) | Belarus (44.5) | Denmark (44.8) | Bulgaria (44.2) |
| 60-75 | Ireland (14.9) | Lithuania (12.7) | Switzerland (14.9) | Belarus (9.6) | Luxembourg (15.0) | Hungary (14.3) | Greece (14.9) | Ukraine (13.8) |
| | Netherlands (14.8) | Republic of Moldova (13.0) | Ireland (14.8) | Republic of Moldova (11.0) | Switzerland (15.0) | TFYR Macedonia (14.3) | Spain (14.9) | Montenegro (13.9) |
| | Slovenia (14.8) | Bulgaria (13.5) | United Kingdom (14.8) | Lithuania (11.6) | Belgium (14.9) | Bosnia and Herzegovina (14.4) | Portugal (14.9) | Belarus (14.0) |
| | United Kingdom (14.8) | Latvia (13.6) | Norway (14.8) | Russian Federation (11.7) | Netherlands (14.9) | Lithuania (14.4) | Italy (14.9) | Republic of Moldova (14.0) |
| | Luxembourg (14.8) | Ukraine (13.6) | Italy (14.8) | Latvia (12.3) | Portugal (14.9) | Albania (14.4) | Ireland (14.9) | Russian Federation (14.0) |
| 75+ | Ireland (9.8) | Republic of Moldova (5.5) | Switzerland (9.7) | Republic of Moldova (5.4) | Belgium (10.0) | TFYR Macedonia (6.6) | France (9.8) | Montenegro (7.5) |
| | United Kingdom (9.8) | TFYR Macedonia (7.4) | United Kingdom (9.6) | Belarus (6.7) | Luxembourg (10.0) | Republic of Moldova (8.9) | Finland (9.8) | TFYR Macedonia (7.5) |
| | Luxembourg (9.7) | Bosnia and Herzegovina (8.3) | Luxembourg (9.6) | TFYR Macedonia (7.1) | Switzerland (10.0) | Bosnia and Herzegovina (8.9) | Spain (9.8) | Republic of Moldova (8.1) |
| | Slovenia (9.7) | Ukraine (8.4) | France (9.6) | Ukraine (7.4) | Netherlands (9.9) | Iceland (9.0) | Austria (9.8) | Ukraine (8.1) |
| | France (9.7) | Serbia (8.5) | Ireland (9.6) | Russian Federation (7.7) | Estonia (9.9) | Ukraine (9.1) | Slovenia (9.8) | Belarus (8.3) |

**Table 1.4** Top five and bottom five countries with the highest and lowest Temporary Dynamic Life expectancy for the period 2010-15 in the selected age ranges for both the sexes, LATIN AMERICA AND THE CARRIBEAN

| Age Range | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | 10 years | | 25 years | | 10 years | | 25 years | |
| | Highest | Lowest | Highest | Lowest | Highest | Lowest | Highest | Lowest |
| 15-60 | French Guiana (44.8)<br>United States Virgin Islands (44.3)<br>Barbados (44.3)<br>Aruba (44.3)<br>Martinique (44.2) | El Salvador (41.5)<br>Haiti (42.2)<br>Nicaragua (42.3)<br>Venezuela (42.4)<br>Colombia (42.6) | French Guiana (44.8)<br>United States Virgin Islands (44.3)<br>Barbados (44.3)<br>Chile (44.3)<br>Martinique (44.2) | Venezuela (41.0)<br>Haiti (41.1)<br>El Salvador (42.0)<br>Trinidad and Tobago (42.1)<br>Colombia (42.3) | Guadeloupe (44.8)<br>French Guiana (44.8)<br>Puerto Rico (44.8)<br>United States Virgin Islands (44.7)<br>Martinique (44.7) | Guyana (42.9)<br>Haiti (43.2)<br>Honduras (43.7)<br>Paraguay (43.9)<br>Trinidad and Tobago (43.9) | French Guiana (44.9)<br>Martinique (44.8)<br>Guadeloupe (44.8)<br>United States Virgin Islands (44.8)<br>Puerto Rico (44.7) | Haiti (42.5)<br>Guyana (43.0)<br>Paraguay (43.5)<br>Saint Vincent and the Grenadines<br>Jamaica (43.7) |
| 60-75 | Guatemala (14.8)<br>French Guiana<br>Martinique (14.6)<br>Panama (14.6)<br>Curaçao (14.6) | Guyana (12.5)<br>Venezuela (12.7)<br>Trinidad and Tobago (13.2)<br>Suriname (13.4)<br>Aruba (13.6) | Martinique (14.6)<br>Panama (14.6)<br>Guatemala (14.5)<br>Guadeloupe (14.5)<br>Dominican Republic | Guyana (12.4)<br>Suriname (12.7)<br>Trinidad and Tobago (12.9)<br>Haiti (13.1)<br>Aruba (13.3) | French Guiana (14.9)<br>Martinique (14.8)<br>Puerto Rico (14.8)<br>United States Virgin Islands (14.8)<br>Guadeloupe (14.8) | Guyana (12.2)<br>Uruguay (13.5)<br>Trinidad and Tobago (13.8)<br>Venezuela (13.9)<br>Saint Vincent and the Grenadines (14.0) | French Guiana (14.9)<br>Martinique (14.9)<br>United States Virgin Islands (14.8)<br>Guadeloupe (14.8)<br>Guatemala (14.7) | Guyana (12.2)<br>Suriname (13.6)<br>Saint Vincent and the Grenadines<br>Haiti (14.0)<br>Trinidad and Tobago (14.1) |
| 75+ | Bolivia (9.7}<br>El Salvador (9.5)<br>Dominican Republic (9.4)<br>Curaçao (9.3)<br>Martinique (9.3) | Guyana (6.7)<br>Venezuela (7.4)<br>Aruba (7.7)<br>Barbados (7.8)<br>Trinidad and Tobago (7.9) | Bolivia (9.6)<br>Brazil (9.4)<br>Guatemala (9.3)<br>Dominican Republic (9.3)<br>Guadeloupe (9.3) | Guyana (6.6)<br>Suriname (7.2)<br>Aruba (7.3)<br>Trinidad and Tobago (7.4)<br>Haiti (7.6) | Bolivia (9.9)<br>Guadeloupe (9.7)<br>French Guiana (9.7)<br>Panama (9.7)<br>Martinique (9.7) | Guyana (6.4)<br>Trinidad and Tobago (8.4)<br>Venezuela (8.5)<br>Saint Vincent and the Grenadines (8.6)<br>Barbados (8.6) | Bolivia (9.8)<br>Martinique (9.8)<br>French Guiana (9.7)<br>Brazil (9.7)<br>Nicaragua (9.7) | Guyana (6.4)<br>Suriname (8.0)<br>Aruba (8.4)<br>Haiti (8.4)<br>Trinidad and Tobago (8.5) |

**Table 1.5** Top five and bottom five countries with the highest and lowest Temporary Dynamic Life expectancy for the period 2010-15 in the selected age ranges for both the sexes, OCEANIA

| Age Range | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | 10 years | | 25 years | | 10 years | | 25 years | |
| | Highest | Lowest | Highest | Lowest | Highest | Lowest | Highest | Lowest |
| 15-60 | Guam (44.7) | Kiribati (42.1) | Guam (44.7) | Kiribati (42.8) | Guam (44.8) | Kiribati (43.5) | French Polynesia (44.8) | Micronesia (43.6) |
| | Samoa (44.7) | Fiji (43.1) | Samoa (44.6) | Fiji (42.8) | Samoa (44.8) | Papua New Guinea (43.7) | Guam (44.8) | Papua New Guinea (43.6) |
| | French Polynesia (44.6) | Micronesia (43.2) | New Caledonia (44.6) | Micronesia (43.2) | French Polynesia (44.8) | Micronesia (43.7) | Samoa (44.8) | Kiribati (43.9) |
| | New Caledonia (44.6) | Papua New Guinea (43.2) | French Polynesia (44.5) | Papua New Guinea (43.3) | New Caledonia (44.7) | Fiji (44.2) | Australia (44.7) | Fiji (44.1) |
| | Australia (44.5) | Tonga (43.6) | New Zealand (44.5) | Tonga (43.6) | Australia (44.6) | Tonga (44.5) | New Caledonia (44.7) | Tonga (44.4) |
| 60-75 | New Zealand (14.8) | Kiribati (12.1) | Australia (14.9) | Fiji (12.2) | Guam (14.9) | Kiribati (13.2) | Australia (14.9) | Micronesia (13.3) |
| | Australia (14.8) | Tonga (12.5) | New Zealand (14.9) | Tonga (12.5) | New Zealand (14.8) | Micronesia (13.4) | Guam (14.9) | Papua New Guinea (13.6) |
| | Guam (14.6) | Micronesia (12.6) | Guam (14.4) | Kiribati (12.6) | Australia (14.8) | Papua New Guinea (13.6) | New Zealand (14.8) | Kiribati (13.6) |
| | French Polynesia (14.5) | Papua New Guinea (12.7) | French Polynesia (14.3) | Micronesia (12.6) | Samoa (14.8) | Fiji (14.1) | New Caledonia (14.7) | Fiji (14.0) |
| | Samoa (14.3) | Fiji (12.9) | Samoa (14.1) | Papua New Guinea (12.8) | New Caledonia (14.7) | Solomon Islands (14.3) | Samoa (14.7) | Tonga (14.2) |
| 75+ | New Zealand (9.7) | Kiribati (6.4) | Australia (9.7) | Micronesia (6.7) | Australia (9.7) | Kiribati (7.1) | Australia (9.8) | Micronesia (7.1) |
| | Australia (9.7) | Micronesia (6.7) | New Zealand (9.7) | Kiribati (6.8) | Guam (9.7) | Micronesia (7.2) | New Zealand (9.7) | Kiribati (7.4) |
| | Guam (9.1) | Tonga (7.1) | Guam (8.8) | Tonga (7.0) | New Zealand (9.6) | Solomon Islands (8.2) | Guam (9.6) | Solomon Islands (8.1) |
| | French Polynesia (9.1) | Papua New Guinea (7.4) | French Polynesia (8.7) | Papua New Guinea (7.4) | Samoa (9.5) | Papua New Guinea (8.2) | Samoa (9.4) | Papua New Guinea (8.2) |
| | Samoa (8.9) | Fiji (7.4) | Samoa (8.6) | Vanuatu (7.5) | French Polynesia (9.4) | Vanuatu (8.6) | New Caledonia (9.3) | Vanuatu (8.3) |

**Table 1.6** Top five and bottom five countries with the highest and lowest Temporary Dynamic Life expectancy for the period 2010-15 in the selected age ranges for both the sexes, NORTHERN AMERICA

| Age Range | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | 10 years | | 25 years | | 10 years | | 25 years | |
| | Highest | Lowest | Highest | Lowest | Highest | Lowest | Highest | Lowest |
| 15-60 | Canada (44.5) | USA (43.7) | Canada (44.5) | USA (43.9) | Canada (44.6) | USA (44.2) | Canada (44.6) | USA (44.3) |
| 60-75 | Canada (14.8) | USA (14.4) | Canada (14.8) | USA (14.5) | Canada (14.8) | USA (14.7) | Canada (14.7) | USA (14.5) |
| 75+ | Canada (9.7) | USA (9.5) | USA (9.5) | Canada (9.4) | Canada (9.7) | USA (9.5) | Canada (9.6) | USA (9.2) |

Although, substantial reduction in mortality has occurred in all the three age groups throughout the years, however, the pace of this mortality change has not occurred evenly across various age intervals as well as across all regions and countries. As such to understand the pace of mortality decline and improvement in TLE in different age and sex groups, we have estimated the annual relative change (ARC) Indices in TLE between the period 2000-2005 to 2010-2015 (10 years) and 1985-1990 to 2010-2015 (25 years) under both observed and dynamic scenario for all the 199 countries under study for males and females separately. It is interesting to note that the results obtained through the ARC indices in temporary life expectancy are found to reveal a similar picture for the countries under study as are discussed under the TLE portion above. As such looking into the constraints of time and space and in order to avoid repetition, we have not presented the tables related to ARC indices and have given just a glimpse of the results obtained through ARC indices in TLE. The analysis shows that the differences in ARC indices between the observed and the dynamic TLE's are found to be much higher in the adult age viz. 15-60 and the older age group 60-75 over both the intervals whereas, this difference is found to be much low in the oldest age group viz 75+. Our study clearly demonstrates this fact wherein for the 10 years interval, the highest differences in ARC indices between the observed and the dynamic TLE for the countries under study ranges from 19.7 in males and 21.8 in females in the age range 15-60 and 24.4 in males and 28.9 in females in the age range 60-75 to only 1.8 in males and 1.5 in females in the age range 75+. A similar picture has been observed over the 25 years period with the pace of mortality decline found to be much faster in the adult and the older age group compared to the oldest age group. This may be attributable to the fact that as a result of increasing longevity, the number of deaths from non-communicable diseases (NCDs) has increased by 42 percent between 1990 and 2013; and the largest increases in the proportion of global deaths took place among the population aged 80 and over (Wan He et al. 2016). Further, our analysis depicts that this decline in the speed of mortality is found to be much more rapid in the developing countries of the regions compared to the developed countries. It has been observed that the highest differences in ARC indices between the observed and the dynamic TLE in the age range 15-60 varies from 5.6 (males) and 5.3 (females) in Africa to 4.9 (males) and 4.8 (females) in Latin America and the Carribean over the 25 years interval. Similarly, this difference in the age range 60-75 varies from 8.7 (males) and 10.6 (females) among the Asian countries to only

7.8 (males) and 7.4 in (females) in Europe. This can be clearly justified by the fact that although the age distributions of the more developed regions continue to be much older than those of the developing world as a result of differing patterns of fertility behavior, mortality experience, and migration, however, developing countries are ageing much faster than the industrialized countries (Laura B. Shrestha; 2000). Thus, with this rapid and continuous declines in death rates in all age ranges, including those aged 60 and older, the world average age of death has increased by 35 years since 1970 (Wan He et al. 2016). As such, the improvement in the speed of mortality decline among the adult and the older population aged 60 and older has also been reflected in the ARC indices in TLE and this finally corresponds to an increase in the temporary life expectancy at these ages and also the expectation of life at birth under dynamic consideration.

## Conclusion

The study examined the temporary life expectancy (TLE) and the annual relative change indices in temporary life expectancy over the past 10 years (2000-2005 to 2010-2015) and 25 years (1985-1990-2010-2015) interval, of the selected 199 countries of the world, under the perspective of dynamic extension of period life table, which takes into account the mortality changes prevailing in a population. Our analysis reveals that both the temporary life expectancy (TLE) and the annual relative change (ARC) indices in TLE have increased under the dynamic scenario as compared to the usual life expectancy in all the age ranges, particularly more in the adult (15-60) and the older (60-75) age group compared to the oldest (75+) age group, which is a clear indication of sharp mortality reduction in these age ranges throughout the period. Further, among all the countries under study, the developing countries of the regions are more prone to this decline as compared to the developed countries. Since our study considers the dynamic extension of a period life table which takes into account the mortality changes prevailing in a population, therefore, we may conclude that this modification in estimate of the probability of death might provide a better assessment of the prevailing mortality of the population under consideration and therefore it will portray a more accurate picture of the demographic shifts prevailing in a population.

## Conflict of Interest

No conflict of interest was reported by all authors in this section.

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