

Future Population Aging in Bangladesh: Economic and Social Aspects

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Abstract

Recently, Bangladesh has entered into a lower-middle-income country and faces various challenges like other developed countries of the world regarding its population. Eventually, aging will become a challenge for its progressive economy and society. This paper aims to identify the future time periods in which the majority of the indices confirm Bangladesh as an aging country. This study estimates various demographic indices to reveal the age structural transition of Bangladesh's population for 2011-2061. Furthermore, it has computed general distribution indices, the aging index, the Billeter index as reproductive indices, and several economic and support dependency ratios. The trend line of the coefficients of inflow, outflow, and exchange of the productive population has been drawn in order to visualize the future workforce. It has been observed that Bangladesh will be an aging country between 2030 and 2035, taking into account major traditional measures of population aging. In this sense, it is a novel finding for policy implications to overcome the upcoming challenges of the inevitable population aging in Bangladesh. To deal with the implications and drivers of population ageing several steps are required to consider by the government and private institutions.

Keywords: Future population aging, Billeter index, Dependency ratios, Index of potential economic support, Coefficients of inflow, outflow, and exchange.

AMS Classification: 91D20, 91B82, 62P25.

1. Introduction

In 2007, UN stated that almost all the countries of the world are experiencing dramatic population alterations due to the declining rate of mortality and fertility (UN, 2007). These alterations are not only illuminated many demographic, social and economic opportunities for a country but also affect its' population structure. An increase in human longevity and a subsequent decrease in fertility and mortality levels may change the age distribution of the population from younger to older. Demographic aging is one of the four "megatrends" that characterize today's world

population - population growth, population aging, urbanization, and international migration (UN, 2020). In most developed countries, these changes are mainly manifested as a rapid expansion of older populations; a phenomenon is often called "population aging" (Ofori-Asenso et al., 2018; Christensen et al., 2009; Zaidi, 2008). It usually occurs when a nation's population structure develops so that a higher proportion of the future population will be in the older age groups (Turner, 2009). However, population aging is not limited to the growing number of older people and decreases the number and proportion of younger people (Zaidi, 2008).

In general, demographic aging is attributed to the increment of longevity and the reduction of fertility. The effects of aging are limited to the sociological aspects such as family life, cultural activities, and health and affect the economic development of a country (Beard et al., 2011; Bloom et al., 2015).

Bangladesh is an excellent example for development practitioners and policymakers, according to a 2018 WB assessment. Bangladesh, the 8th most populous nation in the world, suffers from unfavorable socioeconomic, political, and environmental circumstances, including early female marriage and corruption. It met the conditions to be designated as the United Nations' Least Developed Country in 2015, earning it the title of a lower middle-income nation. By 2024, it should be included on the list (WB, 2019). A wide gender and location gap in the Bangladeshi elderly characteristics has been observed. Bangladesh is one of the few countries in the world where women outlive men on an average (BBS, 2022). The absolute number of older people is enormous and is expected to increase in the next few years. The traditional theoretical support system for the elderly is slowly declining in Bangladesh, and they have sought alternative support from the government, both financial and healthcare (Khan and Leeson, 2006). Since the older population is growing at a considerably faster rate and the life expectancies are increased with the advancement of time, the elderly should not be considered a burden to society (Rahman, Mohsin, & Tareque, 2009). In 2013, Kabir and his team reported that like other developed countries of the world the older people of Bangladesh will challenge the existing health services, family relationships and social security (Kabir et al., 2013). In the twentieth century, the Bangladeshi population was relatively young. The population of Bangladesh has entered the intermediate level of the ongoing demographic aging process at the very beginning of the 21st century. Different conventional population aging measures do not show the same degree of the aging process. The proportion of children and aging index values exhibit approximately one-decade faster-aging process than those measured by the proportion of elderly and median age of the population in Bangladesh. By the end of the 21st century, half of the population will be aged above forty and confirms that Bangladesh will be an aged nation within this century with relatively poor socioeconomic condition (Islam & Nath, 2012).

Some research on population aging in Bangladesh has been done (Kabir et al., 1998; Khan & Lesson, 2006; Rahman, Mohsin & Tareque, 2009 and Kabir et al., 2013), but none of it is based on multiple indices of the data set that the Bangladeshi government has published, according to the literature review mentioned above. Moreover, the aforementioned studies provide brief descriptions of population alteration (Kabir et al., 1998; Khan & Lesson, 2006; Rahman, Mohsin & Tareque, 2009 and Kabir et al., 2013). An extensive sketch encompassing various indices is expected to emerge in distinct prospects of population alterations shielding the analysis by constructing the policies within an immense background (Jackson, 2001). Accordingly, it is provide a general explanation of population changes in Bangladesh by performing various indicators. This motivates to carry out an extensive analysis illustrating the ways in which

Bangladeshi citizens' aging status is changing and the consequences that it has for the country's economic, reproductive, and support systems, as well as its labor force. Various research works identified that Bangladesh would become an aging country soon and face emerging challenges in old age (Kabir et al., 2013). However, none of them can identify the aging time periods of Bangladeshi people, where maximum indices confirm Bangladesh as an aging country. That's why, this study aims to identify the future time periods where the majority of the indices agree with the inevitable aging in Bangladesh in terms of the demographic point of view.

2. Materials and Methods

2.1 Data Source

This study is based on the dataset of "Population Projection of Bangladesh: Dynamics and Trends 2011-2061" (BBS, 2015). The future population was estimated by BBS using the cohort component population projection method. To perform this prediction, they described a methodology that includes five steps for the cohort component method by considering reliable birth, death, and migration data. The assumptions on total fertility rate (TFR) and proportionate age-specific fertility is taken under consideration. Based on these criteria, they adopted three distinct scenarios, namely "Scenario I," "Scenario II," and "Scenario III." They have been recommended that "Scenario II" is more feasible. That way, only "Scenario II," which assumes a steady decline of TFR over the entire period, was taken into consideration in this study. The gathered data were analyzed using the R program and MS Excel 2013 software.

2.2 Population alteration indices

For assessing the population alterations in Bangladesh, various indices were studied that include general population distribution indices (proportion of youth, proportion of elderly persons and proportion of older-olds), reproductive indices (Billeter index), and economic indices (aging index, total dependency ratio, youth dependency ratio, old-age dependency ratio, potential support ratio, parental support ratio, coefficient of inflow, coefficient of outflow, coefficient of exchange, potential economic support index 1 and 2 and dynamic economic aging index). General distribution indices were constructed for the year 2011 to 2061 within five years interval, including the population of youth (<15 years), elderly (≥ 60 years), and older-olds (≥ 75 years). Billeter index (J) is used to describe the reproductive (fecundity) changes that Ernest Billeter proposed in 1954 (Fischer, 2015). For this, the population is subdivided into three groups, namely pre-reproductive (<15 years), reproductive (15-49 years), and post-productive (50+ years). It is to be remembered that a negative value of the Billeter index (J) indicates the population is aging, and juvenescence is envisioned by a positive value (Fischer, 2015; Weber, 2010).

The parental support ratio is considered as an essential parameter for capturing population aging because an advanced family and social care may be necessary for older olds (Ofori-Asenso et al., 2018; Bucher, 2016; Káčerová & Mládek, 2012). The parental support ratio is estimated for examining the social dynamics of population aging because it states the number of older olds (80+) per 100 individuals aged 50-60. This measure predominantly states the "relationship between the generation of parents and their children and as a potential possibility of direct inter-generation assistance." The estimated parental support ratios for the years 2011–2061 are presented in this article.

The dynamic economic aging index is estimated by comparing the size of age groups that enter and exit the productive age categories at any time for interpreting the speed and direction of

population aging. The speed of this process is represented I_{ead} . The positive value of I_{ead} indicates that the population is getting older. The larger value of I_{ead} indicates the faster-aging process. The negative value of I_{ead} indicates that the population is rejuvenating (Káčerová, Ondačková, & Mladek, 2012; Długosz & Kurek, 2009). The population is grouped as a "productive" group to analyze the economic dynamics of population aging. This means that the 'working' age group (15–59 years) and the young (0–14 years old) as well as the old (60+ years old, who are often acknowledged as the post-productive group) refer to the "dependent" population group (BBS, 2015). Social age groups are usually playing an essential role in explicit the aging process of a country. Scholars have different opinions on identifying the socially important age category. Some of them are in favor of 85 or more years of age whereas some other are 80 and above (Długosz & Kurek, 2009; Káčerová & Mládek, 2012; Káčerová, Ondačková, & Mladek, 2012). The age category (75+) has been considered such a social age group in this study. It also computes the total dependency ratio, youth dependency ratio, old-age dependency ratio, and potential support ratio are also measured for the evaluation of the balance between the dependent and active populations. Several scholars rated the category of the productive population very highly in the socio-economic sense (Káčerová & Mládek, 2012; Káčerová, Ondačková, & Mladek, 2012). Due to this reason, it has to judge its alterations as the older generations leave the same (outflow of the productive population) and younger generations enter the category of the productive population (the rate of inflow) (Ofori-Asenso *et al.*, 2018; Káčerová & Mládek, 2012). The inflow, outflow, and exchange coefficients are computed to evince these processes clearly (Bucher, 2016; Dufek, 2006). The coefficient of exchange's value will be <100% when the inflow rate is less than the rate of exit from the productive population (Ofori-Asenso *et al.*, 2018). The perceptible relationship between the age categories of productive and post-productive populations plays a vital role in the economic development of any country. This quantitative relationship is usually estimated by the Index of potential economic support (I_{pes}) (Káčerová & Mládek, 2012). In the context of this country, it applies two different variations of I_{pes} , namely I_{1pes} and I_{2pes} , where I_{1pes} represents a younger productive age group than I_{2pes} .

Summary of indicators for estimating the alterations in Bangladesh's population [Source: (Ofori-Asenso *et al.*, 2018)]

General distribution indices

1. Proportion of youth: Percentage of total population under age 15 years.

$$\frac{P_{(0-14)}}{t(p)} \times 100$$

2. Proportion of elderly persons: Percentage of total population under aged 60 and over.

$$\frac{P_{60+}}{t(p)} \times 100$$

3. Proportion of older-olds: Percentage of total population aged 75 and over.

$$\frac{P_{75+}}{t(p)} \times 100$$

Reproductive indices

1. Billeter index (J): The ratio of difference between the female populations at the child (pre-reproductive) age (0-14) and post reproductive age (50+) and the female population in the

reproductive age (15-49).

$$\frac{[P_{(0-14)}^f - P_{(50+)}^f]}{P_{(15-49)}^f} \times 100$$

Economic indices

1. Ageing index (A_I): The number of persons 60 years old or over (post-productive) per hundred persons under age 15 (pre-reproductive).

$$\frac{P_{60+}}{P_{(0-14)}} \times 100$$

2. Total dependency ratio (tD_R): The ratio of dependents (people who are too young (0-14) or too old (60+) to work) to the number of productive (working, 15-59) population.

$$\frac{[P_{(0-14)} + P_{(60+)}]}{P_{(15-59)}} \times 100$$

3. Youth dependency ratio (yD_R): The number of persons 0 to 14 years per one hundred persons 15 to 59 years.

$$\frac{P_{(0-14)}}{P_{(15-59)}} \times 100$$

4. Old-age dependency ratio (oD_R): The old-age dependency ratio is the number of persons 60 years and over per one hundred persons age 15 to 59 years.

$$\frac{P_{(60+)}}{P_{(15-59)}} \times 100$$

5. Potential support ratio (pS_R): The potential support ratio is the number of persons aged 15 to 59 per person aged 60 or older.

$$\frac{P_{(15-59)}}{P_{(60+)}} \times 100$$

6. Parental support ratio (paS_R): The parent support ratio is the number of persons 75 years old and over per one hundred persons 50 to 60 years.

$$\frac{P_{75+}}{P_{(50-60)}} \times 100$$

7. Coefficient of inflow (K_i): Quantifies the rate at which 10-14 years olds are entering the productive age.

$$\frac{P_{(10-14)}}{P_{(15-59)}} \times 100$$

8. Coefficient of outflow (K_o): Quantifies the rate of outflow of 55-59 year olds from the productive age.

$$\frac{P_{(55-59)}}{P_{(15-59)}} \times 100$$

9. Coefficient of exchange (K_e): Quantifies the change in rates of population entry and exit from the productive group.

$$\frac{P_{(10-14)}}{P_{(55-59)}} \times 100$$

10. Potential economic support index 1: Indicates the number of persons into 15-59 age groups per one hundred persons over 60 years.

$$\frac{P_{(15-59)}}{P_{(60+)}} \times 100$$

11. Potential economic support index 2: Indicates the number of persons into 20-59 age groups per one hundred persons over 60 years.

$$\frac{P_{(20-59)}}{P_{(60+)}} \times 100$$

12. Dynamic economic ageing index (I_{ead}): Draws comparison between the population making entry into the productive population and those exiting.

$$[P_{(0-14)t} - P_{(0-14)t+n}] + [P_{(60+)t+n} - P_{(60+)t}]$$

Where,

I_{ead} Represents Dynamic economic aging index,

$P_{(0-14)t}$ -Share of population aged (0-14) at the beginning of the study period,

$P_{(0-14)t+n}$ -Share of population aged (0-14) at the end of the study period,

$P_{(60+)t}$ -Share of population aged (60+) at the beginning of the study period,

$P_{(60+)t+n}$ -Share of population aged (60+) at the end of the study period,

3. Results

3.1 Changing Aging Process for General distribution indices

In Bangladesh, the total population is changing due to the variations of her' Age structural variation. From BBS report 2022 published in June 2023, it is observed that Bangladesh will have approximately 172 million people in 2022, out of which 49 million people will be under 15 years of age. This indicates that for every 100 people, there will be 28 people in the youth group. The proportion of youth is decreasing over time (Figure 1). With a sustainable decreasing rate, by 2061, only 38 million people will remain in the youth group, and the remaining will be entered either in the working or old age groups.

In contrast, the proportion of elderly is increasing (Figure 1) and is estimated to hit nearly 25% of the total population in 2061, following the start of approximately 7%. In the same year, only 131 million people will be in the working-age group, indicating that 58% of the total population will have the ability to work, and the remaining 42% will depend on the working category. About 25% and 8% are aged either 60 or over and 75+ years old, respectively. The different proportions of elderly and older-old populations are also expected to pose similar circumstances. For example, 20 years before 2061, 15% of the total population will be in the elderly aged group, and 3% will be aged over 75. It is observed that the proportions of older old groups are started to increase since 2011 and gradually increasing over time until 2061, except in 2021 (Figure 1).

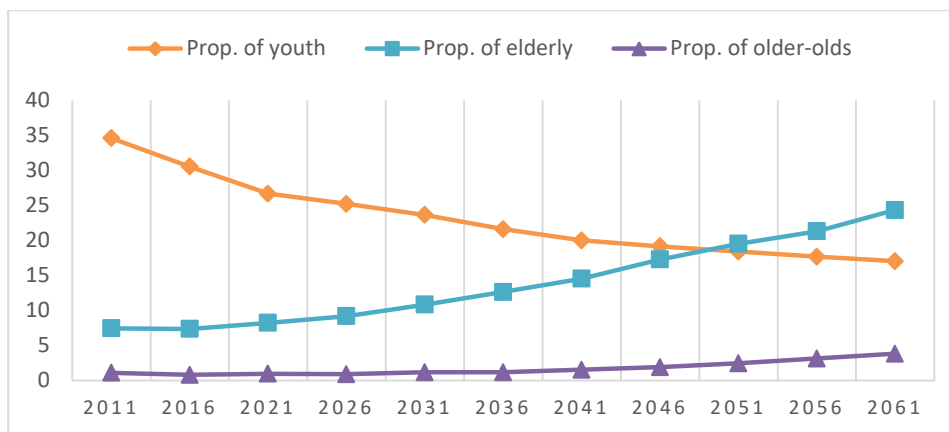


Figure 1: General distribution indices for Bangladesh, 2011-2061.

3.2 Changing Aging Process concerning Billeter index, Median and Aging indices

Over the study period, the Billeter index (J) shows a downward trend. By 2036, this figure would be negative, signaling the starting point of the country's aging process. By the year 2061, this index value will be -54.35%, showing that Bangladesh is an aged nation globally.

In 2011, there was around 22 elderly (60+) out of every 100 young people (0-14 years) (Figure 2, green line). However, the ratio will be increased by more than 150% in 2036 and is expected to reach 142 by 2061. Figure 2 also suggests that for the period (2015-2020) of the projection, the number of persons is capable of reproducing will be equal to the number of persons over age 60 years among every 100 Bangladeshi citizens. According to the median age, an overall increasing trend has been observed from 2011 to 2061. For example, the median age of Bangladesh population in 2011 and 2061 are 23 and 37, respectively. According to the aging Index, an overall increasing trend has also been observed from 2011 to 2061, and it is increasing sharply after 2030. Among these indices strongly manifest the future aging process of the population in Bangladesh.

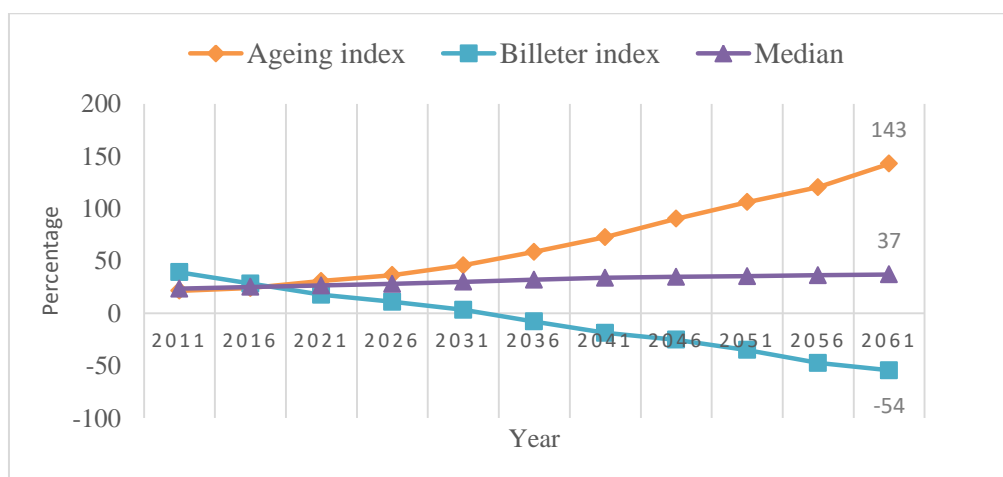


Figure 2: Billeter, Median and Aging indices for Bangladesh, 2011-2061

3.3 Changing Aging Process in terms of Economic Dependency indices

The total dependency ratio (TD_R) decreases from 2011 to 2026, and it becomes stable for a period (2026-2041). Finally, it is increasing and expected to reach the value, which was in 2011. The substantial increment of the Old-age dependency ratio and the decrement of the Youth dependency ratio provide the reason for such behavior of the total dependency ratio. Figure 3 shows that the Old-age dependency ratio is enhancing by year after year to evince this scenario more clearly. Similarly, with the Billeter index and aging Index, the number of Old dependent and Young dependent over every 100 citizens of Bangladesh in the working-age will be approximately equal at the middle of this century (Figure 3).

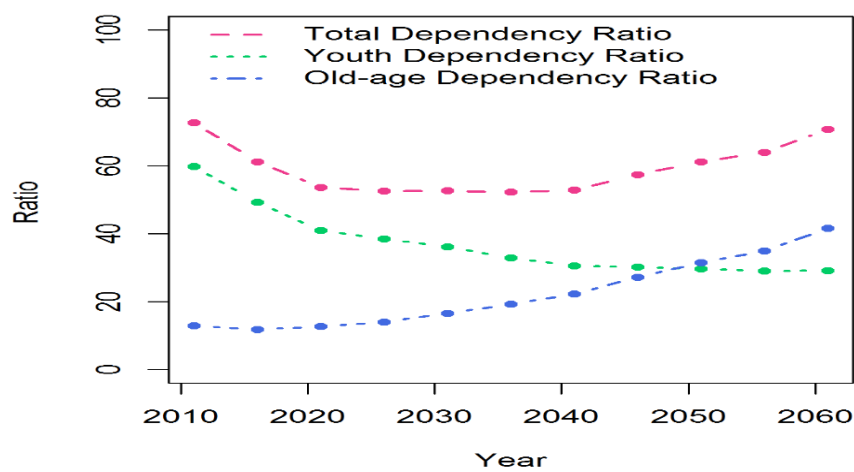


Figure 3: Economic indices (Total, Youth and Old-age Dependency Ratio) of Bangladesh, 2011-2061

3.4 Changing Aging Process concerning Social Support indices

Social age groups are usually playing an essential role in explicit the aging process of a country. The expansion of the relationship among the generation of "parents" (75+) and the generation of their "children" (50 – 60 years) certify the aging of the population in Bangladesh. The number of older olds (75+) every 100 individuals aged 50-60 in 2011 is 28; thus, the parental support ratio is 28. Some inconsistent behavior of parental support ratio is depicted in Figure 4. For example, with an expected decline from 25 older olds per 100 aged people in 2016 to 21 older olds per 100 aged people in 2031, it starts to increase. However, after 2036 the parental support ratio is expected to increase sharply. The number of older olds every 100 aged people is 26 for 2041, whereas the number of older olds will be 54 in 2061 for every aged 50-60 people of Bangladesh. The declining trend of the potential support ratio also affirms the aging of the population in Bangladesh over time. In 2016, 8 persons in productive age every 100 individuals aged in post-reproductive age (Figure 4). After that, the potential support ratio followed a steady decline and predicted to be two productive persons in 2061 from 6 productive people every 100 individuals aged 2031.

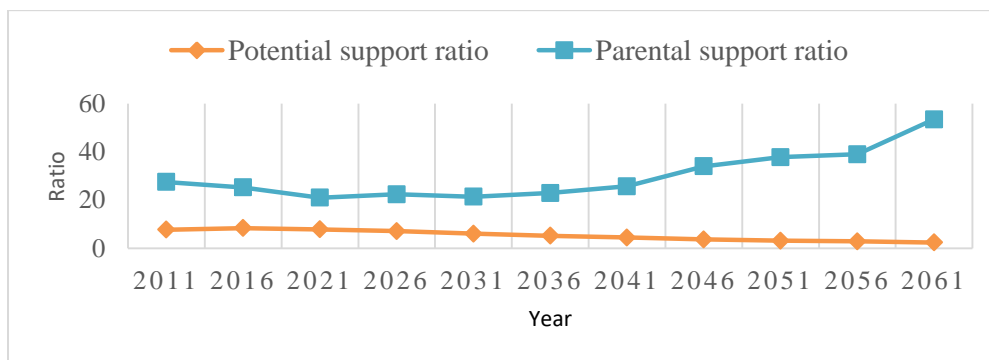


Figure 4: Support Ratios (Potential and Parental) of Bangladesh, 2011-2061

3.5 Changing Aging Process concerning workforce

The coefficient of inflow stands for the number of individuals in the age category 10 to 14 years entering productive ages. The number of persons entering the working force for every 100 people was the highest in 2011 as the time passes it decreases while after 2026 it increases a little bit but again exhibits a steady decline. Figure 5 evinces that the inflow rate (K_i) of youth into the working-age population was about two times more than outflow into the post-productive age group. It indicates that about two persons (10-14) were likely to enter the workforce, for a single person (55-59) likely to exit from this group in 2026. The coefficient of outflow identifies the movement out of 55 to 59 year olds from the productive age category to the post-productive population. The curves indicate the increasing trend in the outflow coefficient, whereas the sign of the inflow rate is negative. After 2051 for some specific period, these two coefficients will be equal so that the number of people entering and exiting the workforce for every 100 people will be the same. Finally, after this situation, the outflow rate will be greater than the inflow rate. The alterations in the proportion of "incoming" to and "leaving" from the productive population are expressed by the coefficient of exchange. The situation shifted inverse exponentially over the projected period. The coefficient of exchange was 475% in 2011. It means that about 475 persons entering the working force for every 100 people exiting. This rate decreases due to the increment of outflow rate and is expected to be minimum in 2061. This can also be inferred that the inflow rate will not be enough to maintain the country's current working force because the coefficient of exchange is approximately 73% in 2061.

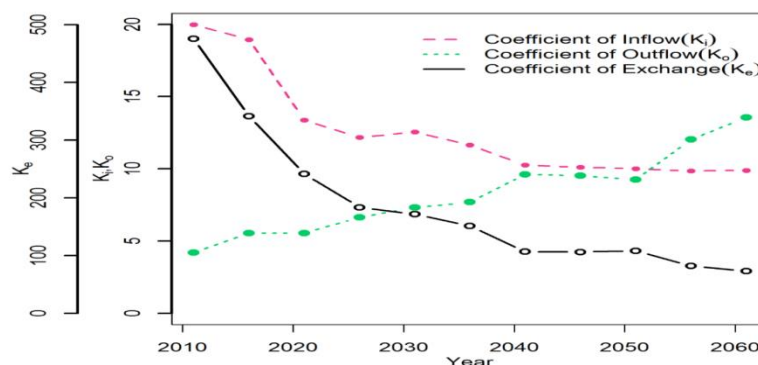


Figure 5: Coefficients of inflow, outflow, and exchange of productive population in Bangladesh, 2011-2061

3.6 Changes in Potential Economic Support indices for Elderly

Both indicators exhibit a similar downward trend (Figure 6). By 2021, Bangladesh will have approximately 790 people in the productive age group for every 100 post-productive persons, but this number is declining and expected to reach 240 persons in 2061. Figure 6 also suggests that for every year, the number of people in productive age, especially 20-59 age group, per 100 post-productive people (I_{2pes}) is less than the number of people in the 15-59 productive age group (I_{1pes}). It has also observed that under the I_{2pes} category, there are approximately six people in productive age per single person in the post-productive age. Similarly, like I_{1pes} , it is predicted to be two persons in 2061. The declining trend of the potential economic support indices confirms the aging population in Bangladesh over time.

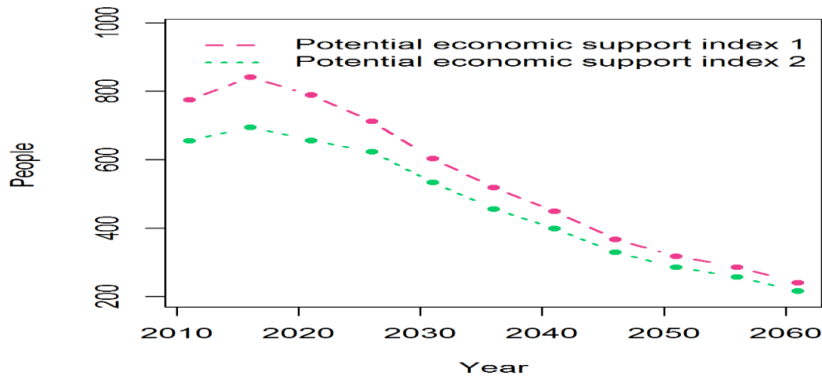


Figure 6: Index of Potential Economic Support in 2011-2061 for Bangladesh

3.7 Speed of Population Aging concerning Dynamic Aging indices

The trend line of the dynamic economic aging index indicates that Bangladesh will never face rejuvenation because of positive values of I_{ead} (Figure 7). From 2021 to 2031, the speed of population aging will increase, and after 2031 it will exhibit a steady situation due to the future expected stable fertility rate.

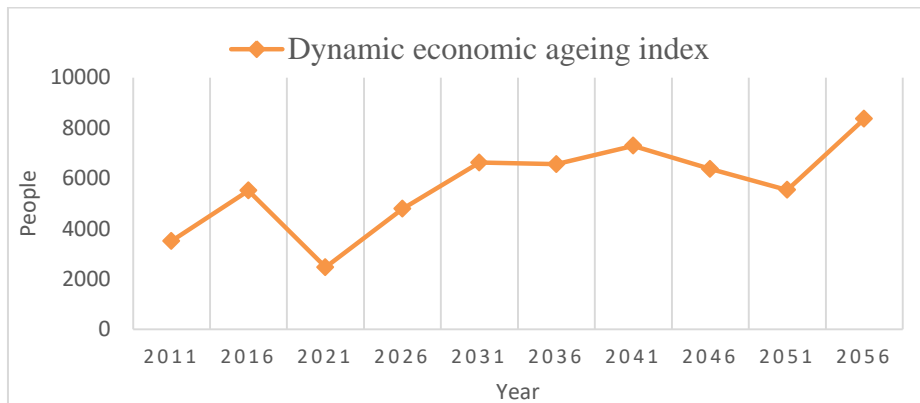


Figure 7: Dynamic Aging indices of Bangladesh, 2011-2061

Many researchers have already mentioned that Bangladesh must be an aging nation shortly from regarding demographic point of view. To the best of the author's knowledge, no researcher has marked the future specific time periods when Bangladesh will become an aging nation. In this study, it has tried to shed light on this issue. In this sense, it is a novel finding for policy implications to overcome the upcoming challenges of the inevitable population aging in Bangladesh. From the above analysis, it is concluded that the majority of the indices agreed that Bangladesh would be an aging country between 2030 and 2035 according to traditional primary measures of population aging (Table 1).

Table 1: Summary of the indices to predict the future time periods of aging in Bangladesh's population

Indices	Cutoff point	Future time periods of aging in Bangladesh
Aging index (AI)	The increasing trend value of AI indicates that the population is aging.	The value of AI is increasing sharply after 2030 than the previous years
Proportion of youth	A population with a value below 30 is typically regarded as old (Shryock & Siegel, 1976).	The value of the proportion of youth will be below 30 in 2021.
Proportion of elderly	Population with a value of the proportion of aged persons ten or more is typically considered old (Shryock & Siegel, 1976).	The value of the proportion of elderly will cross 10 in 2031
Median	A typical aging population has its median age of 30 and over (Shryock & Siegel, 1976).	The value of median age will cross 30 in 2031
Billeter index (J)	A negative value of the Billeter index (J) indicates the population is aging (Fischer, 2015; Weber, 2010).	The value of the Billeter index will be negative after 2031
Potential economic support indices I_{1pes} and I_{2pes}	The declining trend value of I_{1pes} and I_{2pes} indicates that the populations are going to be aging	The value of both indices is dramatically decreasing after 2030 than the previous years.
Dynamic economic aging index (I_{ead})	The positive value of I_{ead} indicates that the population is getting older. The larger value of I_{ead} indicates that the faster is the process of aging.	The value of I_{ead} is increasing rapidly after 2026 than the previous years. So we can consider the rapid aging process of Bangladesh after 2031.

4. Discussions and Implications

This study observed that the proportion of the older people in Bangladesh was less than the global average by 1% in 2016 though it is increasing as time passes. In 2051, the proportion of Bangladeshi people of age 15-24 will be below by 0.25% than the world average, which suggests that the average available policy of demographic transition for facing the future challenges regarding population will not work for Bangladesh (Rahman, Mohsin, & Tareque, 2009). It requires special supports to protest the upcoming problems and maintain its continuing success. Moreover, the reduction rate of youth will exhibit a steady line after 2021, which will give some more time to prepare for the worse consequence after 2051. It has to mobilize accumulated wealth and savings to develop infrastructure, quality education, and vocational training. It need to provide additional importance on female education as the proportion of females will increase in the productive age category to participate in the workforce. The proportion of productive female (15-59) age is greater than that of male during 2011 to 2031; then, it will be identical in the period 2036-2046. Finally, the percentage of the productive male is greater than females for the second half of this century.

On the other hand, the proportion of female older old will have more than that of males. In 2011 it had only 0.88% older-old female, the female and male elderly will be expected to reach approximately 4.28% and 3.42% in 2061. The study of the population distribution manifested that our country will have more older women than men in the future. This result supports the work of Islam and Nath (Islam & Nath, 2012). This perception is coherent with global patterns, usually known as the feminization of aging (Ofori-Asenso et al., 2018; Davidson, DiGiacomo, & McGrath, 2011; Gavrilov & Heuveline, 2003). Due to the decrease in maternal mortality, the progress of knowledge and technology as well as due to biological and behavioral mechanisms, it has released proportionately higher mortality among men, activities such as smoking and lifestyle choices (Gjonça, Tomassini, & Vaupel, 1999; Rogers et al., 2010).

To verify the aging of Bangladeshi people, calculate the aging Index and found an increasing aging trend line. The aging Index was just above 20 in 2011 and projected to exceed 100 by 2051. However, Australia will exceed 100 by 2030 (Ofori-Asenso et al., 2018), and other developed countries like Germany and Japan had experienced this in 2000 (Ofori-Asenso et al., 2018; Gavrilov & Heuveline, 2003). The decrement in the size of the productive population also confirms the future aging scenario. For example, the Billeter index is declining over time and is expected to reach a negative value in 2036. It also suggests that Bangladesh will not face any rejuvenation soon, particularly between now and 2061. Both these indices strongly manifest the future aging process of the population in Bangladesh. Another reason for aging is the continuous reduction of the fertility rate. Bangladesh has gained an almost 64% decline in its fertility rate since 1975. It will decrease further and will drop to 1.9 in 2026 (BBS, 2015). The TFR is expected to be 1.85 births per woman by the end of 2050 (Khan & Leeson, 2006). At present, almost 50% of countries of the world have a sub-replacement fertility rate (UNDP, 2019), and Bangladesh is expected to be on the list by 2026. Due to this reason, Bangladeshi women will get more reproduction-free years and have to utilize this opportunity to increase the working force. It already benefits from a low fertility rate because female employees in the garment sector bring in extra income. Almost 90% of employees in the garments sector are female, and they contribute almost 10% of the total gross domestic product (Ahmed, 2004). So it should ensure more advanced training for female workers to cope with the upcoming machinery-dependent industries.

Due to the successive decrement of the fertility rate, the youth dependency ratio and total dependency ratio initially decline. The total dependency ratio starts to increase after 2040 though the youth dependency ratio is still decreasing because the number of old age individual's increases. This result is consistent with the previous predicted result conducted by Islam and Nath (Islam & Nath, 2012).

The declining mortality rates and the increased survival of life expectancy are other critical factors that subsidize the aging process. The main reason for the increment of the Old-age dependency ratio is the subsequent increment of life expectancy and the reduction of mortality rate among Bangladeshi people. The average life expectancy in 2011 was 67.5 years, increased to 72 in 2017 (Economic Review, 2018), which is predicted to rise by approximately 9% in 2036, and in 2061 it is projected that the average life expectancy will hit 79.5 years. The life expectancy of females is greater than males, and for this reason, the proportion of female old-age is larger than male old-age proportion. The people of Bangladesh will survive 75 years from their birth by 2045-2050 (Khan & Leeson, 2006). The crude death rate (per thousand populations) dropped from 29.70 to 5.1 in 1951-2016 (BBS 1978, 2003, and 2016). Again, the maternal mortality rate (MMR) decreased between 1986 and 2016 (BBS 2006, 2016) from 6.48 to 1.81. The mortality rate is not only

decreased for adults for also reduced for newborn babies, neonatal through the mortality from cardiovascular disease, cancer, diabetes, and chronic respiratory disease approximately constant (Kim et al., 2019). It will have to make more financial investments in the future to support the aging population, which will affect its economic development.

In the above discussions, it is stated that the fertility rate is declining. It will severely affect the parental support ratio, which also impacts social support that older people may consider. Previous studies reported that when older-aged people cannot look after themselves, they usually consider staying in a domestic environment, and it will not become possible due to the subsequent decrement of support ratios that will ask for institutional care. Additionally, it will result in higher treatment costs, a greater demand for resources, increased strain on the pension plan, and growing pressure on the social security system.

Currently, Bangladesh is taking full advantage of its "windows of opportunity" and has a vast workforce. It is achieving a demographic surplus from its aging process, and this amusement of earning will continue over the first three decades of this century (Islam & Nath, 2012). In the recent future, this enormous mass of productive individuals will become dependents as they begin to be aged and leave the workforce. Since 2011, the working force has begun to decline because the trend line of inflow and outflow are opposite to each other, which means the coefficient of inflow is decreasing as the coefficient of outflow increases. This booming outflow rate will reach the productive population to the post-productive age group quickly. From the findings also indicated that Bangladesh would have a significantly reduced workforce by 2056 because of the large number of people in the post-productive population and the limited number of people entering the productive age group. This is also one of the reasons for the higher dependency ratio that is seen. Like other countries of the world, this will reduce productivity and economic output.

In this study, it has examined various demographic indices to evince the population changes in Bangladesh. It applied general distribution indices to describe the proportion of youth, elderly and older-olds, reproductive and aging indices to inspect the future scenario of the post-productive and productive population. For measuring the aspects of dependency of various age groups to the productive age group, economic indices are used as total, youth, and old-age dependency ratios, potential, and parental ratios are used for support indices, and finally, coefficient of inflow, outflow, and exchange to visualize the figure of the future workforce. Hence, it is evident that Bangladesh will enter into an aging country by the early part of the second quarter of the current century and deal with the problem of demographic burden in the future. To address the approaching future implications, social services—primarily health care services—should be improved (Kabir et al., 2013).

The main limitation of this research was the inability of the authors to employ mathematical modeling on time-series data related to population aging.

5. Conclusions

In this study, it has been examined various demographic indices to evince the population changes in Bangladesh. It was applied general distribution indices to describe the proportion of youth, elderly and older-olds, reproductive and aging indices to inspect the future scenario of post-productive and productive population. For measuring the aspects of dependency of various age groups to the productive age group, economic indices are used as total, youth and old age dependency ratios, potential and parental ratios are used for support indices and finally coefficient of inflow, outflow and exchange to visualize the figure of future workforce. A set of indicators

compares the productive population groups and provides information about the growing category of young age groups as well as changes in the number of older age groups. An irreplaceable knowledge for the whole economic sphere is observed from the reciprocal relations of these distinct population ages. To evince the future social welfare (security) status of this country, several quantitative relationships within the "parents" and their "children" are adopted. This study has revealed that a combination of factors including the increment of life expectancy and reduction of mortality rate along with fertility rate is responsible for the age structure of Bangladeshi people and Bangladesh will be an aging country between 2030 and 2035, taking into account major traditional measures of population aging. These kinds of comparisons suggest that intergenerational support or care will be necessary, especially for the older age population groups in the future. These changes will also affect in areas of economic productivity and demand for age-related essential health as well as social care services and multiple approaches are required to consider by government and private institutions. This finding will help the policymakers to design future regulations. In order to address the aforementioned issues, it is recommended that a strong social welfare system be put in place and that all primary healthcare facilities, whether in rural and urban regions, closely adhere to the age-attentive guidelines provided by the WHO.

Scopes of Further Research

In this paper, it was touch slightly on the issue of population aging and its consequences in economy and the support to the elderly. Mathematical modeling with time-series data on population aging will shed more light on identifying the nature and trends of the population aging process. A comprehensive study on the impact of population aging on the policies of finance, pensions, poverty, assistance and health care, retirement policy will be helpful to show the overall picture of the problem.

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Declarations

Author contributions: MKH conceptualized this study, design, acquisition of literature, analysis, and interpretation of data, drafting the manuscript, revised and finalized the manuscript. SYA supported extensively developing the study concept, acquiring literature, analyzing data, and writing, editing, and finalizing the manuscript. MNI and MTU conceived the study, guided drafting, and substantially contributed to the design, analysis, and interpretation of data, and revised the draft critically for important intellectual contents. All authors read and approved the final manuscript.

Conflict of interest: The authors declare no conflict of interest.

Ethical approval: Ethical approval was not necessary for this study as only publicly available aggregate population data were used.

A list of abbreviations

UN = United Nations

WB = World Bank

BBS = Bangladesh bureau of Statistics

UNDP = United Nations Development Program

WHO = World Health Organization

References

- [1] Ahmed, F. E. (2004). The Rise of the Bangladesh Garment Industry: Globalization, Women Workers, and Voice. *National Women's Studies Association Journal*, 16(2), 34-45.
- [2] BBS (1978). *Statistical Pocket Book of Bangladesh*, Bangladesh Bureau of Statistics, Ministry of Planning: Dhaka.
- [3] BBS (2003). *Population Census 2001, National Report (Provisional)*, Bangladesh Bureau of Statistics, Ministry of Planning: Dhaka.
- [4] BBS (2006). *Report on Sample Vital Registration System- 2003*, Bangladesh Bureau of Statistics, Ministry of Planning: Dhaka.
- [5] BBS (2015). *Population Projection of Bangladesh: Dynamics and Trends 2011-2061*. Bangladesh Bureau of Statistics, Ministry of Planning: Dhaka.
- [6] BBS (2016). *Statistical Pocket Book of Bangladesh*, Bangladesh Bureau of Statistics, Ministry of Planning: Dhaka.
- [7] BBS (2022). *Bangladesh Sample Vital Statistics 2022, Key Findings*, Bangladesh Bureau of Statistics, Ministry of Planning: Dhaka.
- [8] Beard, J. R., Biggs, S., Bloom, D. E., Fried, L. P., Hogan, P., Kalache, A., . . . eds. (2011). *Global population aging: Peril or promise*. Geneva: World Economic Forum.
- [9] Bloom, D. E., Chatterji, S., Kowal, P., Lloyd-Sherlock, P., McKee, M., Rechel, B., . . . Smith, J. P. (2015). Macroeconomic implications of population aging and selected policy responses. *Lancet*, 385(9968), 649-657. doi:[https://doi.org/10.1016/S0140-6736\(14\)61464-1](https://doi.org/10.1016/S0140-6736(14)61464-1).
- [10] Bucher, S. (2016). Aging of the population in the Russian Federation: The current trends and indicators. *Herald of the Russian Academy of Sciences*, 86(2), 97-104. doi: <https://doi.org/10.1134/S1019331616020027>.
- [11] Christensen, K., Doblhammer, G., Rau, R., and Vaupel, J. W. (2009). Aging populations: the challenges ahead. *Lancet*, 374(9696), 1196–1208. doi: 10.1016/S0140-6736(09)61460-4.
- [12] Davidson, P. M., DiGiacomo, M., and McGrath, S. J. (2011). The Feminization of Aging: How Will This Impact on Health Outcomes and Services? *Health Care for Women International*, 32(12), 1031-1045. doi: 10.1080/07399332.2011.610539.
- [13] Długosz, Z., and Kurek, S. (2009). Population aging and its predictions for 2030 in the Małopolskie Voivodship compared to Poland and Europe. *Moravian Geographical Reports*, 1(17), 2-18.
- [14] Dufek, J. (2006). Age structure and the burden carried by the productive population of the Czech Republic. *Agricultural Economics*, 52, 67-75.
- [15] *Economic Review* (2018). Finance Division, Ministry of Finance, Dhaka, Bangladesh.
- [16] Fischer, F. (2015). Demographic aging in Baden-Wuerttemberg, a federal state of Germany - Population projection and small scale analysis. *Innovative Journal of Medical and Health Science*, 5(4), 136-145. doi: 10.15520/ijmhs.2015.vol5.iss4.78.136-145.
- [17] Gavrilov, L. A., and Heuveline, P. (2003). Aging of Population. In P. Demeny and G. McNicoll (Eds.). *The Encyclopedia of Population*.
- [18] Gjonça, A., Tomassini, C., and Vaupel, J. W. (1999). Male-female Differences in Mortality in the Developed World. Max Planck Institute for Demographic Research.
- [19] Islam, M. N., and Nath, D. C. (2012). A Future Journey to the Elderly Support in Bangladesh. *Journal of Anthropology*, 1-6. doi:10.1155/2012/752521.
- [20] Jackson, N. (2001). A policy makers-guide to population aging: key concepts and issues. Policy Research Paper, Department of Families and Community Services, Canberra.
- [21] Kabir, R., T. A. Khan, H., Kabir, M., and Rahman, M. T. (2013). Population aging in Bangladesh and its implication on health care. *European Scientific Journal*, 9(33), 34-47.

- dio: <https://doi.org/10.19044/esj.2013.v9n33p%25p>.
- [22] Kabir, Z., Szebehely, M., Tishelman, C., and Chowdhury, A. M. (1998). Aging trends - Making an invisible population visible: The elderly in Bangladesh. *Journal of Cross-Cultural Gerontology* 13(4):361-78, February 1998, 13(4), 78-361.doi: 10.1023/a:1006536217913
- [23] Káčerová, M., and Mládek, J. (2012). Population Aging as Generation Substitutions (Economic and Social Aspects). *Ekonomický časopis*, 3(60), 259-276.
- [24] Káčerová, M., Ondačková, J., and Mladek, J. (2012). A comparison of population aging in the Czech Republic and the Slovak Republic based on generation support and exchange. *Moravian Geographical Reports*, 20(4), 26-38.
- [25] Khan, H. T., and Leeson, G. W. (2006). The Demography of Aging in Bangladesh: A Scenario Analysis of the Consequences. *Hallym International Journal of Aging*, 8(1), 1-21.doi: 10.2190/HA.8.1.a.
- [26] Kim, D.-Y., Wala, Z., Islam, S., Islam, R., and Ahn, M. (2019). Clinical characteristics and outcomes of ST-segment elevation myocardial infarction in a low-income setting in rural Bangladesh. *IJC Heart & Vasculature*, 23.doi:10.1016/j.ijcha.2019.100376.
- [27] Ofori-Asenso, R., Zomer, E., Curtis, A. J., Zoungas, S., and Gambhir, M. (2018). Measures of Population Aging in Australia from 1950 to 2050. *Population Aging*, 11, 367–385.doi: <https://doi.org/10.1007/s12062-017-9203-5>.
- [28] Rahman, K. M., Mohsin, M. I., and Tareque, I. (2009). Trends of population aging from 1950-2050: A comparative study between Bangladesh and World. *Pakistan Journal of Social Science*, 6(1), 6-10. <https://medwelljournals.com/abstract/?doi=pjssci.2009.6.10>
- [29] Rogers, R. G., Everett, B. G., Saint, J. M., and Krueger, O. M. (2010). Social, behavioral, and biological factors, and sex differences in mortality. *Demography*, 47(3), 555–578.doi: 10.1353/dem.0.0119.
- [30] Shryock, H. S., Siegel, J. S. and Associates, A. (1976). 'The Methods and Materials of Demography', Academic Press, Inc. Harcourt Brace Jovanovich, Publishers.
- [31] The World Bank (2019). The World Bank in Bangladesh. Retrieved June 26, 2020, from <https://www.worldbank.org/en/country/bangladesh/overview#3>
- [32] Turner, A. (2009). population aging: What should we worry about? *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 364(1532), 3009–3021.doi: <https://doi.org/10.1098/rstb.2009.0185>.
- [33] UN (2007). 'World Population Ageing 2007', New York, United Nations.
- [34] UN (2020). World Population Aging 2019, New York: United Nations, Department of Economic and Social Affairs, Population Division.
- [35] UNDP (2019). UNDP in Bangladesh. (United Nations Development Programme) Retrieved June 28, 2020, from <https://annualreport.undp.org/>
- [36] Weber, L. (2010). *Demographic Change and Economic Growth: Simulations on Growth Models*. Berlin: Springer-Verlag.
- [37] Zaidi, A. (2008). Features and challenges of population aging: The European perspective. Vienna: European Centre.