Sains Malaysiana 53(11)(2024): 3791-3801
http://doi.org/10.17576/jsm-2024-5311-21

Projection of Older Population in Malaysia by Physical Disability Status

(Unjuran Penduduk Tua di Malaysia Mengikut Status Ketidakupayaan Fizikal)

MUHAMMAD AZIZ[1], MOHD AZMI HARON[1,*], ZAILAN SIRI[1] & NORISZURA ISMAIL[2]

[1]Institute of Mathematical Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur, Malaysia
[2]School of Mathematical Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

Received: 28 June 2024/Accepted: 27 September 2024

ABSTRACT

In Malaysia, the well-being of individuals with disabilities remains a concern. Addressing the situation of individuals with disabilities and the aging population is critical for the future of Malaysia. This study utilizes a multistate approach to assess the transition probability of disability among older adults in Malaysia. We utilize information from the National Health Morbidity Survey (NHMS) 2019 to parameterize a functional Markov Model and employ a cohort-component projection method for projecting the Malaysian population for 2020-2040 by disability status. The probability of becoming disabled increases with age and is higher for females than males. By 2040, it is anticipated that Malaysia will have nearly 1.7 million disabled older persons experiencing at least two of the six physical limitations delineated in the National Health Morbidity Survey 2019. With advancing age, there is a progressive increase in the likelihood of experiencing disability. The projected 13% of Malaysians aged 65 and above by 2040 emphasizes the necessity for enhanced eldercare social security.

Keywords: Disability; long-term care; Malaysian older adults; NHMS 2019; population projection

ABSTRAK

Di Malaysia, kesejahteraan orang kurang upaya (OKU) masih menjadi kebimbangan. Menangani situasi kekurangan upaya dan populasi warga emas adalah kritikal untuk masa depan Malaysia. Kajian ini menggunakan pendekatan berbilang keadaan untuk menilai kebarangkalian peralihan status kekurangan upaya dalam kalangan warga emas di Malaysia. Maklumat daripada Tinjauan Morbiditi Kesihatan Kebangsaan (NHMS) 2019 digunakan untuk memparameterkan Model Markov fungsi dan kaedah unjuran komponen kohort untuk mengunjurkan populasi Malaysia bagi tempoh 2020-2040 mengikut status kekurangan upaya. Kebarangkalian menjadi OKU meningkat dengan usia dan lebih tinggi bagi wanita berbanding lelaki. Menjelang 2040, Malaysia dijangkakan akan mempunyai hampir 1.7 juta warga emas OKU yang mengalami sekurang-kurangnya dua daripada enam batasan fizikal yang digariskan dalam Tinjauan Morbiditi Kesihatan Kebangsaan 2019. Dengan pertambahan usia, kebarangkalian mengalami kekurangan upaya akan meningkat secara progresif. Unjuran 13% rakyat Malaysia berumur 65 tahun ke atas menjelang 2040 menekankan keperluan untuk jaminan sosial penjagaan warga emas yang lebih baik.

Kata kunci: Jagaan jangka panjang; kekurangan upaya; NHMS 2019; orang tua Malaysia; unjuran populasi

INTRODUCTION

Department of Statistics Malaysia (DOSM) (2022) reports that the Malaysian population is experiencing an increase in life expectancy at birth, with men and women living to an average of 71.3 and 75.8 years, respectively. This demographic shift is leading to a notable increase in the number of older individuals in Malaysia, with estimates projecting that the proportion of adults aged 65 and above will elevate from 5% in 2010 to 14.5% in 2040. The demographic doubling of the population aged 65 and older, progressing from 7% to 14%, unfolded over an extensive timeline of 115 years in developed nations like France and 85 years in Sweden (Tyng & Hamid 2015). In contrast, developing countries such as Thailand and Malaysia are anticipated to reach a similar demographic shift within a significantly shorter span, projecting approximately 20 years according to Mutalib, Ismail and Miskiman (2023).

The aging of the population is undoubtedly a significant alarm for Malaysia. This progression carries profound implications for the delivery of long-term care (LTC)

services. As individuals age, they become more susceptible to disability and may require assistance with both daily and non-daily tasks. The World Health Organization (2001) asserts that disability is any physical, mental, or sensory condition that restricts an individual's abilities. Disability affects individuals of all ages. Among the older population, the risk of disability is higher due to the natural aging process and the accumulation of chronic health conditions (Vaughn et al. 2019). Higher disability incidence in this population may result in poorer quality of life (Groessl et al. 2019) as well as higher healthcare costs (Xu & Chen 2019).

The decline in functional capacity among older adults may be attributed to changes in physiological functions throughout their lifespan, leading to the manifestation of disabilities in both Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (Carmona-Torres et al. 2019). In most Asian cultures, it is a longstanding norm for family members to care for aging relatives (Yusuf et al. 2018). The evolving landscape of family dynamics, which frequently results in older adults living alone, dictates the requirement for additional daily supervision (Albarrán, Alonso-González & Grané 2020). In Malaysia, Yusuf et al. (2018) estimate that approximately 43% of adults aged 65 and older will require LTC, with 50% needing care for three years or more and 20% projected to spend at least five years in a nursing facility.

The implication of Malaysia's aging population includes an increasing burden on public finances as the government needs to spend more on healthcare, social security, and pensions (Korwatanasakul, Sirivunnabood & Majoe 2021). The situation also puts a strain on the eldercare system. Presently, a deficit in adequately trained caregivers and an absence of economically viable eldercare services have been identified (Ng & Indran 2021). In Malaysia, the provision of care services is predominantly overseen by the Department of Social Welfare Malaysia (JKM), alongside privately operated nursing homes and non-governmental organizations. However, there is a growing concern regarding the awareness and future affordability of financing LTC for older adults, particularly in relation to healthcare expenses and LTC services (Hamdy & Yusuf 2018). Residential fees are not levied by public care establishments while private for-profit care institutions typically impose monthly fees ranging from RM1001 to RM3000 (Goh et al. 2013).

Atella et al. (2021) stress that the present aging phenomenon is predominantly driven by the confluence of increasing life expectancy, decreasing fertility rates, and changing patterns of migration. Advancements in medical and health technologies also contribute to the rise of older individuals in developing nations such as Malaysia. Numerous studies have focused on the LTC requirements, disability among older adults, as well as the projection of the aging population (Kwon, Lee & Hur 2013; Vaish, Patra & Chhabra 2020). However, there is a significant gap pertaining to disability specifically in the context of the aging population in Malaysia.

This study discusses the Malaysian older population projection by disability status. Utilizing the cohort-component projection method for the population estimate, Malaysian disability data from the National Health Morbidity Survey (NHMS) 2019 are assessed through a discrete-time multistate model established following the framework by Rickayzen and Walsh (2002). A key strength of this method lies in its ability to estimate transitional probabilities between disability states (improvement or deterioration) using cross-sectional data, even in the absence of longitudinal data. This is achieved by incorporating assumptions on mortality and disability transitions. As a result, population projections obtained through Rickayzen and Walsh's approach account for the dynamic nature of disability prevalence. To the best of our knowledge, this study represents the inaugural utilization of such data to construct a disability transition multistate model, subsequently integrating it into a cohort-component population projection method. The authors modify a functional Markov model equation and parameters to suit the NHMS 2019 data to convey a comprehensive sense of the aging and physical capability situation of the older population in Malaysia. The projections of older Malaysians through 2040 can be used to guide the planning and preparation of LTC services, which is vital for ensuring that Malaysians receive the necessary care and assistance.

MATERIALS AND METHODS

DATA

In the absence of credible longitudinal data on disability transitions among Malaysians, this study utilizes cross-sectional information from National Health Morbidity Survey 2019. NHMS 2019 is a national survey focusing on non-communicable diseases, risk factors of non-communicable diseases, and healthcare demand conducted by Institute for Public Health, National Institutes of Health, Ministry of Health, Malaysia. The dataset for NHMS 2019 encompasses 16,689 respondents, employing a two-stage stratified cluster sampling methodology to ensure the national representativeness of participants. The primary stratum encompasses all 13 states and 3 Federal Territories in Malaysia, while the secondary stratum encompasses both urban and rural areas within the primary stratum.

The NHMS's disability module is a set of questionnaires that follows International Classification of Functioning, Disability, and Health framework by the Washington

Group on Disability Statistics (WG). The WG Short Set on Functioning (WG-SS) has been demonstrated to be a trustworthy instrument for assessing disability, displaying substantial consistency between self-reported and proxy-reported data (Boggs et al. 2022). For the analysis in the present study, eliminating adolescent respondents and ones with missing information relating to disability module, we extracted a total of 11,674 responses, each representing adults aged 18 years and above.

DISABILITY CATEGORIZATION

The WG-SS encompasses six functional domains: seeing, hearing, mobility, cognition, communication, and self-care. Drawing on NHMS data to derive transition probabilities, disability is operationally defined as encountering difficulties in any of the six specified domains. Respondents are classified into two groups: Those without any disability and those in one of three distinct disability states. The disability states, which are mild, moderate, and severe correspondingly encompass individuals facing challenges in one, two to three, and four to six physical domains, as reported in the survey.

Table 1 shows the prevalence of Malaysian by disability status. Generally, females have higher rates for the mild and moderate disability states compared to males for most age groups. This exhibits that older females in Malaysia are more susceptible to disability than their male counterparts. It is consistent with other studies that have suggested that females have higher disability rates due to their higher life expectancies and lower mortality rates. The propensity for developing LTC disability demonstrates a steeper incline with each advancing year among females in contrast to males (Fong, Shao & Sherris 2015). Despite experiencing greater longevity, females tend to spend longer duration living with disability (Li, Shao & Sherris 2017).

MULTISTATE DISABILITY TRANSITION MODEL

The fundamental method employed in this model is a discrete-time Markov model. Ideally, the utilization of a longitudinal data set would enable the computation of transition probabilities by the application of a maximum likelihood estimation. In the absence of longitudinal data, the estimation of transition probabilities in the multistate model involves assuming a functional form for these probabilities as established by Rickayzen and Walsh (2002). This approach entails modifications to existing formulas to estimate three key probabilities: the probability of transitioning from a healthy state to disability, the probability of improvement from a disabled state, and the mortality rate among individuals with disabilities. Subsequently, parameters for each formula are determined in order to repeat the initial prevalence rates for a period of one year. The parameters included in this model have been selected specifically to accurately reproduce the prevalence rates of disability status from NHMS 2019. This analysis is subject to some limitations in terms of data availability. Consequently, we make an implicit assumption of a stationary population structure in order to calculate transition probabilities. This study employs an optimization approach utilizing the Solver tool in Microsoft Excel version 2404.

As this study accommodates NHMS 2019 data for three disability states, five states are required in total including the healthy state and the state denoting death. This paper utilizes the notation $n: n = 0,1,2,3$ to represent different disability states, where 1, 2, and 3, correspond to able/no disability, mild disability, moderate disability, and severe disability, respectively. Figure 1 provides an illustration of the model using this definition. Arrows represent potential transitions between states that have been defined. Death, deterioration, and improvement are the three different types of transition probabilities that are integrated in the model.

THE PROBABILITY OF DEATH

For each disability state, it is assumed that both genders are susceptible to mortality based on the Malaysian Abridged Life Tables 2019 obtained from DOSM (2021). Alternatively, those who fall within the moderate and severe disability state are assumed to be susceptible to additional mortality rates. This means that as an individual's disability status worsens, the mortality rates of individuals with disabilities rise. $AddMort(x,n)$, the assumed additional mortality rate imposed on individuals aged x who are in disability state n is given by:

$$AddMort(x,n) = \frac{M}{1 + 1.1^{50-x}} \times \frac{max(n-1,0)}{5}, \qquad (1)$$

where M denotes the maximum additional mortality applied. The function, in line with the work of Rickayzen and Walsh (2002) illustrates several characteristics such as the poor age reliance in disability-related mortality in relative to normal mortality. Moreover, additional mortality is minimal at lower ages and there is no additional mortality assumed for individuals in the mild disability state. A pivotal age of 50 and a steepness factor of 1.1 were integral components of the approach utilized. Leung (2004) cites a report by the Society of Actuaries Long-Term Care Valuation Insurance Methodologies Task Force (1995) that advises a maximum additional mortality of 0.15. This study adopts the suggestion accordingly.

THE PROBABILITY OF DETERIORATION

Next, consideration is made for health deterioration that indicates transition to a worse disability state. There are two transitions considered here. One situation arises when an

TABLE 1. Prevalence rates (per 1000) by disability state

	Male				Female			
Age Group	Able	Mild	Moderate	Severe	Able	Mild	Moderate	Severe
18-24	981.82	13.99	4.20	0.00	960.84	31.63	3.01	4.52
25-34	885.97	109.50	1.81	2.71	837.21	155.04	6.89	0.86
35-44	820.81	170.52	4.82	3.85	743.16	239.94	13.69	3.22
45-54	738.37	238.88	15.51	7.24	594.23	368.80	25.25	11.72
55-59	626.99	291.04	69.52	12.44	529.68	313.30	143.94	13.08
60-64	599.69	236.26	134.36	29.69	477.16	284.22	201.04	37.58
65-69	574.36	227.71	158.42	39.51	396.43	295.63	258.86	49.08
70-74	481.61	256.60	170.70	91.10	319.75	236.59	305.45	138.21
75-79	364.49	130.84	401.87	102.80	223.15	258.05	370.05	148.75
80+	141.00	200.26	305.67	353.08	137.04	123.34	361.29	378.33

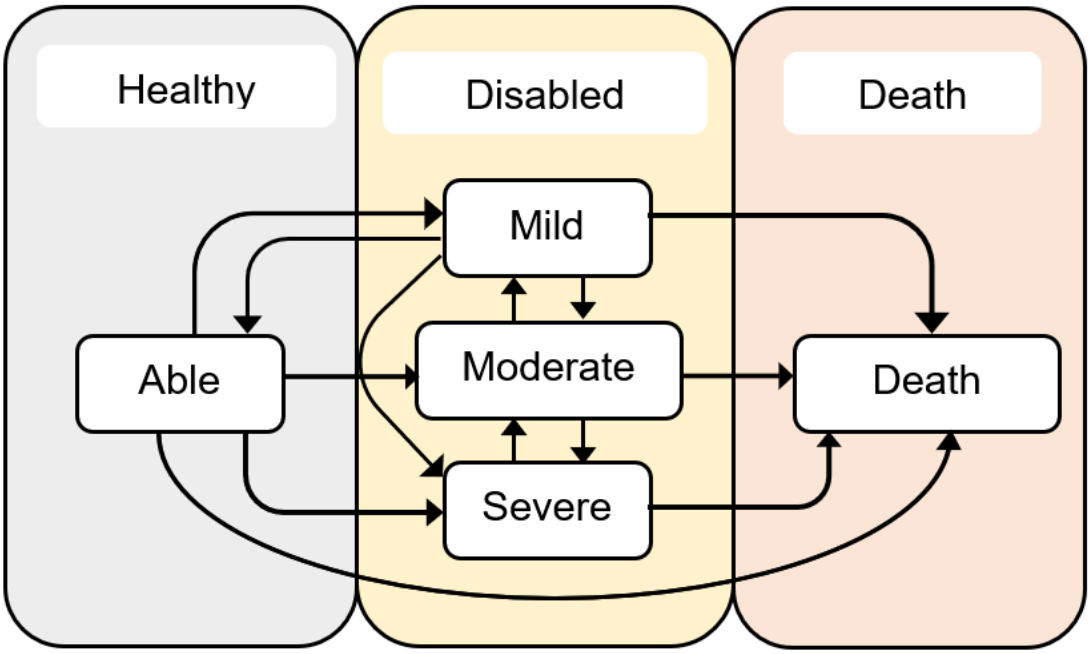

FIGURE 1. A multistate Markov model as a description of disability

individual who was previously healthy meets the condition to be disabled. The second situation involves individuals who are currently disabled and subsequently experience a decline in their state of disability. The logistic formula for probability that a healthy individual aged x becomes disabled is given as:

$$NewDis(x) = \left(A + \frac{D-A}{1+B^{C-x}}\right) \times \left(1 - \frac{1}{3} \cdot e^{-\left(\frac{x-E}{4}\right)^2}\right), \quad (2)$$

Parameters D and A signify the maximum and minimum probability being considered. In addition, parameters B and C assess the rate of probability increase depending on the age. The supplementary parameter E specifies the age at which the equation exhibits a 'kink'. To ensure reasonable estimations, we establish boundary conditions for B and C, such as requiring B to be greater than 1 and setting C within the range of 50 to 100, in accordance with the guidelines suggested by Kwon, Lee and Hur (2013). The estimated parameters for Equation (2) are given in Table 2.

Subsequently, the conditional transition probability from state 0 to state n for each $n = 1,2,3$ given that individuals aged x are newly disabled is calculated by:

$$Severity(x,n) = \frac{W(n) \times f(x)^{n-1}}{Scale(x)}, \quad (3)$$

where

$$f(x) = P + \frac{1-P}{1+Q^{R-x}}, \quad (4)$$

and

$$Scale(x) = \sum_{n=1}^{3} W(n) \times f(x)^{n-1}, \quad (5)$$

where disability state widths are denoted by $W(n)$. Variables P, Q and R demonstrate the correlation of disability on age. Including the $Scale(x)$ term allows us to set the arbitrary value of $W(1)$ to 1 while ensuring that the probabilities add up to one. The estimated parameters for Equations (4) and (5) are given in Table 3.

Additionally, the model permits for deterioration of individuals who are already in mild and moderate disability states. Rickayzen and Walsh (2002) suggest a straightforward function to accommodate this deterioration. The probability of an individual in disability state m deteriorating to disability state n is F^m times the probability that an individual with no disability deteriorates to disability state n is given as:

$$Deteriorate(x,m,n) = Deteriorate(x,0,n) \times F^m, \quad (6)$$

where

$$Deteriorate(x,0,n) = NewDis(x) \times Severity(x,n), \quad (7)$$

The deterioration factor is denoted by F. In their study, Kwon, Lee and Hur (2013) utilized a deterioration factor of 1.05 without making any distinction between male and female LTC recipients. In contrast, Bueno (2013) adopted a gender-specific approach in which he utilized a factor of 1.1561 for males and 1.1830 for females, based on the results reported by Rickayzen and Walsh (2002). This study employs a deterioration factor of 1.20 for males and 1.25 for females.

THE PROBABILITY OF IMPROVEMENT

The improvement in disability is confined to one lower disability state over the span of a year, and only in the event that the individual survives and does not worsen to higher disability state. Rickayzen and Walsh (2002) employed a fixed rate of 10% per year as the improvement rate for each disability state. Bueno (2013), Kwon, Lee and Hur (2013), and Leung (2004) allow for variable improvement rates based on different disability states. This paper follows the same approach, with modifications suited to the Malaysian data. The improvement rates are as in Table 4.

While the improvements, notably those in the mild disability state may appear generous, this is in part to offset the fact that the model does not include the comprehensive range of improvements. In other words, the model only permits improvement to the healthy state from the mild disability state although in actuality, individuals from each state have the possibility to improve to the healthy state, but this is highly improbable. Upon establishing transition probabilities suited to NHMS data, the Malaysian population can be projected to estimate the number of individuals in each disability state through 2040.

Table 5 shows that the percentage of difference in prevalence rates for males and females appears to be rather low. To assess the goodness of fit of the model, the discrepancy between the prevalence rates obtained by the model and the actual NHMS 2019 prevalence rates is evaluated. Exhibited discrepancies across all age groups and disability states were minimal, generally falling below 5%. The discrepancies are reasonable for younger age groups. However, a marginally greater percentage disparity exists. That is due to the very low prevalence in that group that a marginally different projection can result in substantial difference. Fluctuations are seen for both genders at ages of 75 and above in all disability states. Considerable variances are noticeable for males aged 75 to 79 in mild disability states while females aged 80 and above exhibit similar outcomes. That is due to prevalence of NHMS mildly disabled individuals that fluctuate at higher ages. This result is deemed reasonable as not much information is present from NHMS 2019 regarding disabilities of respondents aged 75 and above. The model's estimated prevalence rates may not perfectly align with the observed NHMS prevalence rates, however, marginal variances observed in Table 5 suggest that any discrepancies to the initial population structure are negligible. In the future, using more reliable and extensive data is expected to enhance the goodness of fit in the model.

COHORT-COMPONENT POPULATION PROJECTION

Provided that the model prevalence rates have been computed to reflect NHMS 2019 data, the initial population requisite for the number of individuals in each disability state according to each age and gender. For initial projection phase, this study utilizes estimates of 2019 populations acquired from DOSM (2023). As reported in United Nations (2022), the total fertility rate falls to 1.83 births per woman in 2019 and this serves as the baseline rate for this projection. To facilitate population projection, a fixed net migration of 50,000 per year is assumed. This study assumes that the age distribution of migrants to remain consistent as structured in DOSM (2022) estimate. The projection approach utilized in this study is based on the methodology presented by Rickayzen and Walsh (2002). It is a cohort-component projection method, which involves distinct applications for males and females. The model generates, based on a set of assumptions, an estimate of population who are healthy or disabled.

TABLE 2. Estimated parameters for $NewDis(x)$

Parameter	Male	Female
A	0.01385	0.01595
B	1.20256	1.19385
C	73.33763	72.34097
D	0.30426	0.32771
E	77.76135	76.71100

TABLE 3. Estimated parameters for $Severity(x, j)$ and $f(x)$

Parameter	Male	Female
P	0.9336	0.70491
Q	1.09979	1.13365
R	75.25489	76.20764
$W(1)$	1	1
$W(2)$	0.71611	0.81358
$W(3)$	0.48895	0.59698

TABLE 4. Improvement assumptions

Improvement	Mild to healthy	Moderate to mild	Severe to moderate
Recovery rate	10%	7.5%	5%

TABLE 5. Difference (%) in prevalence rates between model and data

	Male				Female			
Age Group	Able	Mild	Moderate	Severe	Able	Mild	Moderate	Severe
18-24	0.32	2.00	2.32	0.00	0.53	3.16	3.05	1.90
25-34	0.33	4.19	3.31	1.32	0.40	2.56	4.22	0.34
35-44	0.36	2.05	6.02	1.71	0.76	2.82	2.34	0.72
45-54	0.49	1.42	3.42	1.65	1.04	1.94	2.40	1.54
55-59	1.16	2.96	1.54	0.11	0.92	1.61	0.11	0.40
60-64	0.02	0.96	1.47	1.48	0.03	0.18	0.10	2.31
65-69	0.79	2.19	0.37	0.08	0.53	0.97	0.30	0.16
70-74	0.02	0.09	1.24	2.16	0.67	1.52	0.45	2.38
75-79	2.39	17.00	4.55	0.19	1.49	0.59	1.02	0.64
80+	5.36	4.82	0.17	4.09	1.06	13.51	0.83	5.12

Conventional cohort-component projection formula is as follows:

$$P_t = P_{t-1} + B_t - D_t + M_t \quad (8)$$

where P_t is population at time t, B_t is births at time t, D_t is deaths at time t and M_t is net migration at time t. This study utilizes approach deviates from the conventional formula where components like P_t, P_{t-1} and D_t incorporate disability transition probabilities, allowing for a more dynamic representation of disabled population change.

RESULTS

PROJECTION RESULTS

An approach to assess the overall accuracy of the projection methodology involves comparing the resulting projections with the Malaysian population projections obtained from DOSM (2022) and the United Nations' (2022) World Population Prospect (WPP). This can identify any significant inconsistencies between the model's projections and the published demographic data by DOSM and WPP. According to the model's projections, the population in 2040 is estimated to be of 19,843,330 males and 19,276,410 females. The projections indicate that both male and female populations will experience growth in the next two decades, with the male population consistently higher than the female population. The most significant growth in the male population is expected to occur between 2020 and 2030, whereas for the female population, it is expected to be between 2025 and 2030.

Table 6 presents the estimated number of individuals aged 65 and older. Based on the model's estimates, the population of individuals aged over 65 is expected to increase over the next two decades. In 2020, the estimated projections for males and females are 1,109,400 and 1,219,980, respectively. By 2040, the estimated population for males is expected to reach 2,323,380 while for females it is expected to reach 2,607,980. The estimates suggest that the female population aged 65 and above will consistently be higher than the male population in that age group.

DISABLED OLDER ADULTS' PROJECTIONS

The projected number of older adults with moderate to severe disabilities in Malaysia is expected to exceed 1,694,640 by 2040. Although the projections start with approximately 873,590 individuals in 2020 and gradually increase over the next two decades as depicted in Table 7, the prospect of having nearly 1.7 million disabled individuals in the future who require help with their daily activities is concerning. A significant observation includes that females tend to have a higher number of disabled individuals when compared to males, a finding that is consistent with previous research. At the end of the projection period, the number of females in the two disability states is projected to exceed seven figures reaching 1,005,280. This can be attributed to females having a longer life expectancy than males, resulting in them living longer in old age and experiencing more disabilities.

DISCUSSION

Since LTC needs are more likely to affect the older population, it is pertinent to examine the proportion of older adults in moderate and severe disability states. In addition, females display a slightly greater probability of experiencing disability and requiring assistance with ADLs compared to males. This can be attributed to the fact that females generally have a higher life expectancy, while males exhibit higher mortality rates. Consequently, females tend to live longer, leading to a heightened propensity for an extended duration in a state of disability. The model's projection of slightly over 39,119,743 in population in 2040 is consistent with the WPP projection. This provides a better understanding of the burden of disability among older adults, who may require more intensive and specialized forms of care and support. JKM currently oversees ten Rumah Seri Kenangan and two Rumah Ehsan throughout Peninsular Malaysia (Chung, Pazim & Mansur 2020). Regardless, the projection of 4,931,360 older adults, with almost 1,694,640 requiring helps with ADL in 2040, stresses that social services will need to be expanded in terms of assisted living facilities, community care, and programs that address loneliness and isolation.

In 2020, 7% of Malaysia's population was aged 65 and above as illustrated in Figure 2. This study projects that by 2040, this demographic cohort will constitute 13% of the overall Malaysian population. As the older population grows, there will be increased pressure on the healthcare system to cater to their specific needs, such as geriatric care, chronic disease management, and age-related health issues. The model's estimates of the aging population can be valuable in informing policy decisions and resource allocation for healthcare and social welfare programs, which will likely experience increased demand as the population ages. A noteworthy finding by DOSM (2020) indicates that 7.7% of older individuals in Malaysia are living below the poverty line, surpassing the national poverty rate of 5.6%. This highlights significant economic challenges faced by the populace, prompting a closer examination of socio-economic disparities at the national level. By analyzing the prevalence of disability in this age group, policymakers and healthcare providers can tailor their services to meet the specific needs of older adults with functional limitations.

TABLE 6. Model, WPP, and DOSM population estimates

		Overall Population (000′s)						
		2020	2021	2022	2025	2030	2035	2040
Male	Model	16,984.28	17,172.37	17,357.52	17,890.39	18,686.46	19,340.92	19,843.33
	WPP	16,986.17	17,166.53	17,341.83	17,865.77	18,656.77	19,326.64	19,870.03
	DOSM [a]	16,966.20	17,000.50	17,039.80				
	DOSM [b]	17,535.80			18,702.10	19,764.60	20,713.10	21,562.70
Female	Model	16,202.62	16,394.37	16,584.40	17,138.28	17,985.61	18,704.58	19,276.41
	WPP	16,213.82	16,407.34	16,596.39	17,162.26	18,030.80	18,783.36	19,409.43
	DOSM [a]	15,481.20	15,575.80	15,658.30				
	DOSM [b]	16,246.80			17,320.50	18,297.80	19,166.10	19,940.50
Total	Model	33,186.90	33,566.74	33,941.92	35,028.67	36,672.07	38,045.50	39,119.74
	WPP	33,199.99	33,573.87	33,938.22	35,028.03	36,687.57	38,110.00	39,279.46
	DOSM [a]	32,447.40	32,576.30	32,698.10				
	DOSM [b]	33,782.60			36,022.60	38,062.40	39,879.20	41,503.20
		Population above 65 (000′s)						
Male	Model	1109.40	1164.41	1222.52	1405.47	1719.72	2028.68	2323.38
	WPP	1105.78	1154.06	1204.89	1381.95	1699.85	2032.19	2375.63
	DOSM [a]	1066.80	1111.30	1144.30				
	DOSM [b]	1202.50			1586.40	2034.20	2497.20	3024.30
Female	Model	1219.98	1279.74	1343.49	1544.62	1900.19	2264.45	2607.98
	WPP	1222.11	1280.21	1341.34	1549.83	1924.48	2325.53	2727.01
	DOSM [a]	1124.50	1178.80	1219.40				
	DOSM [b]	1240.30			1621.50	2049.20	2519.70	2987.50
Total	Model	2329.38	2444.15	2566.01	2950.09	3619.91	4293.14	4931.36
	WPP	2327.89	2434.27	2546.22	2931.78	3624.33	4357.72	5102.64
	DOSM [a]	2191.20	2290.20	2363.70				
	DOSM [b]	2442.80			3207.90	4083.40	5016.90	6011.80

[a]Current population estimate, [b]20-year population projection based on 2020 census data

TABLE 7. Estimates of moderate and severe disabled adults aged 65 and above

Population (000's)	2020	2025	2030	2035	2040
Male	355.42	416.50	97.83	591.50	689.36
Female	518.16	606.93	722.61	862.14	1005.28
Total	873.59	1023.43	1220.44	1453.65	1694.64

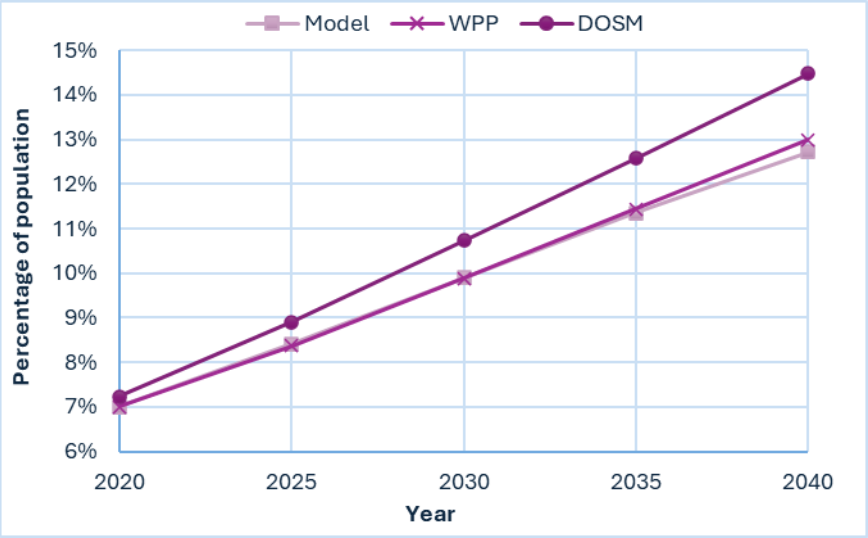

FIGURE 2. Percentage of estimated individuals aged 65 and above

The increasing number of older citizens will place additional strain on pension and social security systems. Additionally, JKM has introduced a number of programs to support older people, such as the Bantuan Warga Emas program, which provides financial assistance to low-income older people. Additionally, actuaries can utilize disability probabilities information along with the older population projections to develop Malaysia's first LTC insurance policy. To mitigate the impact of an aging population, authorities must prioritize the promotion of policies that encourage healthy and active aging and invest in healthcare and social services. One significant proposition involves investing in preventive healthcare programs to encourage healthy lifestyles. This could involve public awareness campaigns promoting balanced diets, regular physical activity, and preventive health screenings. Additionally, implementing policies that discourage tobacco use and excessive alcohol consumption can significantly contribute to healthier aging Malaysians. By addressing these challenges proactively, Malaysia can better prepare for its demographic shift and ensure a sustainable and thriving society in the future.

The limitations of this research include the dataset used for assessments in this research comprises cross-sectional information from NHMS 2019. We believe that longitudinal experience data will yield more accurate results. To achieve this, it is necessary to collect and manage pertinent data that can help enhance projections. In actuarial and health analysis, it is commended to establish conditions using objective data to ensure accuracy and reliability. Furthermore, our analysis solely relies on data concerning ADLs categorized by age and gender. It is crucial to emphasize that this study does not incorporate variables such as family background, income, work experience, and other factors as inputs into our model.

CONCLUSIONS

The findings of this study lead to the conclusion that with advancing age, there is a progressive increase in the likelihood of experiencing disability. Moreover, the probability of females experiencing disability and necessitating assistance in their daily lives is slightly higher than that of males. The model also produces estimates of the future Malaysian population that are conclusively reasonable. Having close to 1,694,640 disabled older adults in 2040 with females making up 1,005,280 of them should serve as a wake-up call for policymakers and healthcare providers to act swiftly and decisively to address the needs of the disabled population. In light of these findings, a compelling suggestion emerges: The development of LTC insurance policies tailored to address the potential needs of future disabled older populations.

ACKNOWLEDGMENTS

This research is conducted as part of PhD research project funded under Skim Latihan Akademik Bumiputra by the Ministry of Higher Education, Malaysia which focuses on disability in the elderly and LTC insurance in Malaysia. The authors are grateful for the demographic data that is obtained from the Department of Statistics, Malaysia. We thank the Director-General of Health Malaysia for his permission (NMRR-23-02064-GBC) to use National Health Morbidity Survey 2019 data that is provided by the National Institute of Health. The datasets presented in this article are not readily available because access to the datasets in the present study is limited due to agreements made with the National Institute of Health, Ministry of Health, Malaysia.

REFERENCES

Albarrán, I., Alonso-González, P.J. & Grané, A. 2020. Long term care insurance pricing in Spanish population: A functional data approach. *The European Journal of Finance* 26: 258-276.

Atella, V., Belotti, F., Kim, D., Goldman, D., Gracner, T., Piano Mortari, A. & Tysinger, B. 2021. The future of the elderly population health status: Filling a knowledge gap. *Health Economics* 30: 11-29.

Boggs, D., Kuper, H., Mactaggart, I., Bright, T., Murthy, G.V.S., Hydara, A., McCormick, I., Tamblay, N., Alvarez, M.L., Atijosan-Ayodele, O., Yonso, H., Foster, A. & Polack, S. 2022. Exploring the use of Washington group questions to identify people with clinical impairments who need services including assistive products: Results from five population-based surveys. *International Journal of Environmental Research and Public Health* 19(7): 4304.

Bueno, L.P.V. 2013. Brazilian long term care plan: An evaluation based on the Singaporean model. MSc Thesis, City University London, CASS Business School, London.

Carmona-Torres, J.M., Rodríguez-Borrego, M.A., Laredo-Aguilera, J.A., López-Soto, P.J., Santacruz-Salas, E. & Cobo-Cuenca, A.I. 2019. Disability for basic and instrumental activities of daily living in older individuals. *PLoS ONE* 14(7): e0220157.

Chung, C.F., Pazim, K.H. & Mansur, K. 2020. Ageing population: Policies and programmes for older people in Malaysia. *Asian Journal of Research in Education and Social Sciences* 2(2): 92-96.

Department of Statistics Malaysia. *Abridged Life Tables Malaysia, 2019-2021*. https://www.dosm.gov.my/portal-main/release-content/abridged-life-tables-malaysia-2019-2021 (Accessed on 11 January 2023).

Department of Statistics Malaysia. *Abridged Life Tables Malaysia, 2020-2022*. https://www.dosm.gov.my/portal-main/release-content/abridged-life-tables-2020-2022 (Accessed on 11 January 2023).

Department of Statistics Malaysia. *Household Income Estimates and Incidence of Poverty Malaysia 2020.* https://www.dosm.gov.my/portal-main/release-content/household-income-estimates-and-incidence-of-poverty-report-malaysia-2020 (Accessed on 4 February 2023).

Department of Statistics Malaysia. *Migration Survey Report 2020.* https://www.dosm.gov.my/portal-main/release-content/migration-survey-report-malaysia-2020 (Accessed on 4 February 2023).

Department of Statistics Malaysia. *Population Quick Info.* https://pqi.stats.gov.my/searchBI.php (Accessed on 4 February 2023).

Fong, J.H., Shao, A.W. & Sherris, M. 2015. Multistate actuarial models of functional disability. *North American Actuarial Journal* 19(1): 41-59.

Goh, Z.Y., Lai, M.M., Lau, S.H. & Ahmad, N. 2013. The formal and informal long-term caregiving for the elderly: The Malaysian experience. *Asian Social Science* 9(4): 174-184.

Groessl, E.J., Kaplan, R.M., Rejeski, W.J., Katula, J.A., Glynn, N.W., King, A.C., Anton, S.D., Walkup, M., Lu, C.J. & Pahor, M. 2019. Physical activity and performance impact long-term quality of life in older adults at risk for major mobility disability. *American Journal of Preventive Medicine* 56(1): 141-146.

Hamdy, M.S. & Yusuf, M.M. 2018. Review on public long-term care services for older people in Malaysia. *Malaysian Journal of Science Health & Technology* 2: 35-39.

Korwatanasakul, U., Sirivunnabood, P. & Majoe, A. 2021. *Demographic Transition and Its Impacts on Fiscal Sustainability in East and Southeast Asia.* https://www.adb.org/publications/demographic-transition-impacts-fiscal-sustainability-east-southeast-asia (Accessed on 11 January 2023).

Kwon, H.S., Lee, C.S. & Hur, J.S. 2013. Projecting the cost of long-term care insurance in Korea. *Asia-Pacific Journal of Risk and Insurance* 7(1). https://doi.org/10.1515/2153-3792.1163

Leung, E. 2004. Projecting the needs and costs of long-term care in Australia. *Australian Actuarial Journal* 10(2): 343-385.

Li, Z., Shao, A.W. & Sherris, M. 2017. The impact of systematic trend and uncertainty on mortality and disability in a multistate latent factor model for transition rates. *North American Actuarial Journal* 21(4): 594-610.

Mutalib, Z.A., Ismail, M.F. & Miskiman, N. 2020. Spatial analysis: Ageing population of multi-ethnic in rural area, Malaysia. *Proceedings of the 2020 Asia–Pacific Statistics Week, Bangkok, Thailand.*

Ng, R. & Indran, N. 2021. Societal narratives on caregivers in Asia. *International Journal of Environmental Research and Public Health* 18(21): 11241.

Rickayzen, B.D. & Walsh, D.E. 2002. A multi-state model of disability for the United Kingdom: Implications for future need for long-term care for the elderly. *British Actuarial Journal* 8(2): 341-393.

Society of Actuaries Long-Term Care Valuation Insurance Methods Task Force. 1995. Long-term care valuation insurance methods. *Transactions of the Society of Actuaries* 47: 599-773.

Tyng, C.S. & Hamid, T.A. 2015. Population ageing and the Malaysian Chinese: Issues and challenges. *Malaysian Journal of Chinese Studies* 4(1): 1-13.

United Nations Department of Economic and Social Affairs Population Division. 2022. *World Population Prospects 2022: Summary of Results*. New York: United Nations.

Vaish, K., Patra, S. & Chhabra, P. 2020. Functional disability among elderly: A community-based cross-sectional study. *Journal of Family Medicine and Primary Care* 9(1): 253-258.

Vaughn, C.B., Jakimovski, D., Kavak, K.S., Ramanathan, M., Benedict, R.H., Zivadinov, R. & Weinstock-Guttman, B. 2019. Epidemiology and treatment of multiple sclerosis in elderly populations. *Nature Reviews Neurology* 15(6): 329-342.

WHO. 2001. *International Classification of Functioning, Disability, and Health (ICF)*. Geneva: World Health Organization.

Xu, X. & Chen, L. 2019. Projection of long-term care costs in China, 2020-2050: Based on the Bayesian quantile regression method. *Sustainability* 11(13): 3530.

Yusuf, M.M., Ruslan, N.A., Hamdy, M.S. & Basah, M.Y.A. 2018. Measuring the awareness on financing long term care cost among public and private sector employees in Malaysia. *The Journal of Social Sciences Research* Special Issue 6: 1252-1256.

*Corresponding author; email: azmiharon@um.edu.my