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Trajectories of Cognitive Ageing among Thai Later-Life Adults: The Role of Education Using the Characteristics Approach

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Abstract

People are living longer and functioning better than at the same age in prior decades, and those aged 60 years and older are often assumed to have similar levels of health and functioning to each other. This study analyzed health and social data from the 2016 Survey of Population Change and Well-being in the Context of Aging Society using the characteristics approach. This method determines variation in the speed of cognitive ageing - assessed through a measurement integrating memory and numeracy, in relation to education levels. A higher education was found to be statistically significantly associated with better cognitive ageing. Great disparities existed in cognitive functioning between those with a below-primary level of education and those with higher education levels. Men tended to have higher scores than women in cognitive function at 60 years of age, but women had a much slower trajectory of cognitive decline associated with ageing. The characteristics approach provides a quantitative perspective on how social gradients can affect people at older ages.

Keywords

Cognitive ageing; characteristics approach; gender differences; speed of ageing

Introduction

Most studies on ageing populations have relied on an assumed benchmark of being considered "old" or "aged" on reaching the age of 60 or 65 years. People of these ages are expected to have the same level of capacity or frailty as each other, especially in terms of health and functioning. This traditional conceptualisation of age is no longer representative of the current situation, with life expectancy increasing and levels of health improving. A series of studies by Sanderson and Scherbov (2007; 2008; 2010) has addressed this changing paradigm.

An issue with traditional measures is that improvements in health and well-being are disregarded because chronological age is the characteristic being highlighted. Sanderson and Scherbov (2013), by contrast, have explored a multidimensional approach to ageing through the introduction of age-specific characteristics that can vary over time and between societies. Their framework integrates varying characteristics into a common form of comparable years of age or α-ages (alpha-ages). This characteristics approach, which uses educational attainment as the point of comparison, has been applied previously on physical health outcomes such as hand-grip strength, chair-rise speed, and walking speed (Sanderson, Scherbov, Weber & Bordone, 2016; Weber, 2016).

The current paper focuses on cognitive health indicators, particularly tasks covering memory and numeracy, which are collectively identified as principal cognitive functions. Level of

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achievement on these cognitive task types is more determinative of the probability of mild cognitive impairment (Ichimura, Shimizutani & Hashimoto, 2009). Much of cognitive ability may be attributable to biological features and consequences. Cognition and its impairments have been noted to contribute to morbidity (Welmerink, Longstreth, Lyles & Fitzpatrick, 2010) and to mortality (Andrade, Corona, Lebrão & Duarte, 2014). Ageing regarding this aspect of health has been considered more over the years with the increasing availability of data. Previous definitions of successful ageing have been deficient because cognitive performance or functioning was not properly considered although it is a central feature of living autonomously among people of advanced ages (Fiocco & Yaffe, 2010). As cognition is integrated further into the analysis of ageing, it has to be stressed that not all people undergo cognitive decline in the same way considering that such decline is dependent on personal and social contexts (Hayden et al., 2011).

Education and cognitive function

Studies on the social aspect of cognition utilise a variety of measures depending on survey data, such as that available from the German Socio-Economic Panel (SOEP), the English Longitudinal Study of Ageing (ELSA), and the World Health Organization's (WHO's) Study on Global AGEing and adult health (SAGE) among others. Through the use of surveys, more explorations are being done to identify how subgroups among those at least 60 years old differ in terms of functioning. A particular dimension that is often examined in terms of health studies is socioeconomic status (SES).

SES is a laden concept. It is sometimes considered a composite of education, occupation, and income (Adler et al., 1994), but more often, education is taken as distinct because of its impact on health and other outcomes. From a biological perspective, obtaining higher levels of educational attainment may have a bearing on the development of the brain itself (Stern, 2002), and may be protective even at older ages. Apart from the biological dimension, many studies also observe the value of education for cognitive ability from a social perspective (Bordone, Scherbov & Steiber, 2015; Skirbekk, Loichinger & Weber, 2012). The relationship of income, along with employment and type of occupation, with cognitive health and function remains inconclusive (Reed et al., 2011; Singh-Manoux et al., 2011).

The context of the studies described is high-income countries. This is mainly due to the availability of data. Developing countries are also experiencing population ageing, but this issue is less recognised because data is unavailable or has become available only recently as in the case of Thailand.

The Thai context

Thailand's population, which includes a larger proportion of people aged at least 60 years, is notable in relation to developed countries (Knodel & Chayovan, 2008). Developments in social and health policy, particularly in the family planning programme, which has shown an impact starting from the late 1960s (Kamnuansilpa, Chamratrithirong & Knodel, 1982), have influenced population growth and structure for decades. One manifestation of this was the unexpected below-replacement fertility level in the 1980s (Hirschman et al., 1994). With continuing improvements in terms of health across ages, people are living longer; therefore, the proportion of older people has been increasing. In 2015, the number of the Thai population aged 60 years and above was 10.7 million, compared to around 1.1 million in 1950 (United Nations, 2019). Men aged 60 years had a life expectancy of around 15 years during the period

1950-1955; for 2020-2025, this figure is estimated to be around 21 years (United Nations, 2019). For the same period, life expectancy for women has increased from around 19 to 25 years.

In this context, a number of studies have addressed the factors associated with health outcomes and the status of older people, partly to determine their probable social and healthcare needs (Karcharnubarn, Rees & Gould, 2013; Quashie & Pothisiri, 2018; Suttajit et al., 2010). The government of Thailand recognises these needs and many policies and programmes have been developed to cater for them. As with cognitive function screening, which is continuing to be tested and developed for use in the Thai context, studies on cognitive health and decline in general remain scarce.

The aim of this paper is to analyze differences in the speed of cognitive ageing according to educational attainment in people aged 60 years and above in Thailand. Cognitive functioning and capacity are often differentiated between societies, but comparing individuals within a society is appropriate in order to gauge how much they are affected by variations in educational attainment. This is done through the characteristic ageing approach, which divides the population into specific subgroups according to the varying trajectories of the ageing process.

Data and Method

Data

This study relies on data from the 2016 national-level Survey of Population Change and Well-being in the Context of Aging Society (PCWAS) conducted by the College of Population Studies, Chulalongkorn University, to document the situation of women (15-49 years old) and older people (defined as 60 years and older) residing in private households. Households were selected through a multistage clustered probability sampling technique, which involved the selection of sampled provinces, followed by sampled districts, then sampled enumeration units, and then sampled households within each of these units. In each sampled household, all age-eligible household members who were not ill, deaf, unable to communicate, or presenting with any sign of dementia were approached for a face-to-face interview. The final sample consisted of 8,415 reproductive-aged women and 7,451 older people from 15,222 households within the 21 sampled provinces (College of Population Studies, 2018).

The sample included in the current study is individuals aged 60 years and above who successfully participated in a cognitive assessment without others' presence or assistance (N=6,511). The sample was further restricted to individuals who provided complete responses for all variables included in this study. Therefore, cases with any missing data were excluded from the analysis. Missing data accounted for 1.3% of the total sample, resulting in an analytic sample size of 6,301, of which 58.6% were older women.

Measurements

Principal cognitive function

Principal cognitive function was measured in two domains: memory and numeracy. Memory was assessed by immediate and delayed word-recall tests, in which respondents were asked to listen to three words in the Thai language (translated as 'tree', 'car' and 'hand') and to repeat them, in any order, immediately afterwards. One point was given for each correct word.

Approximately 5-10 minutes after the immediate word-recall test, during which respondents were asked to perform another task (a serial sevens subtraction test), respondents were asked to recall the three words from the immediate recall task. Again, one point was given for each correct answer. Combining both tasks, the possible total score ranged between 0 and 6.

Numeracy was assessed through a serial sevens subtraction task starting from 100. Unlike the generic serial sevens task of the Mini-Mental State Examination (MMSE), respondents in the PCWAS survey were posed a hypothetical situation: *Suppose that you had 100 baht*; *how much would be left after a purchase of a 7-baht item?* Respondents who provided a correct answer were probed with a successive question: *From the remainder of 93 baht, how much would be left after another purchase of a 7-baht item?* One point was given for a correct answer at each step, with a maximum score of 2.

The scores from the two cognitive tasks were summed to create the principal cognitive function variable, with a total score ranging from 0 to 8 and higher scores denoting better cognitive function. We recognise the limitation that could stem from using only two domains of cognitive function. However, based on Cronbach's alpha, the reliability coefficient for the two components of the principal cognitive function variable (0.62) indicates acceptable internal consistency (Hinton, McMurray & Brownlow, 2014). It is also important to note that the principal cognitive function variable does not represent a diagnosis of cognitive disease, such as Alzheimer's disease or other dementia. Rather, it describes the cognitive performance of older adults based on their score on the survey items.

Education

Education was included in the analysis as a categorical variable indicating whether the respondent had less than a primary education (including no education), had completed a primary education (fourth to sixth grades) only, or also had a beyond-primary education.

Age

Age was calculated using the difference between date of interview and date of birth.

Methods and strategy

The study's analysis comprised two parts. The first concerned the construction of a characteristic schedule for principal cognitive function, which was prepared separately for men and women. Having two genders and three levels of education, we therefore produced six characteristic schedules for principal cognitive function.

To construct the characteristic schedule, we used multiple linear regression models. We explored the age pattern of the characteristic, whether it was linear or non-linear, and whether there was any interaction effect of education and age or quadratic age. We also tried including income, location of residence (urban/rural), and disability (assessed by activities of daily living) into the models, but none except income was statistically significant. Although our multicollinearity diagnostic test indicated that income was not significantly correlated with education, our final model, verified by R-square, did not include income in order to present only the main effect of education. Our final regression analyzes included age, non-linear age, and education to model the decline in principal cognitive function of older persons. The regression specification for both men and women can be written as:

$$Y_i = \beta_0 + \beta_1 \text{age} + \beta_2 \text{age}^2 + \beta_3 \text{primary} + \beta_4 \text{beyondprimary} + \varepsilon_i \quad (1)$$

In the equations, i indicates individual and ε_i indicates an error term which is assumed to be independent and normally distributed with a common variance of σ^2.

The second part of this study involves the computation of α-ages: characteristic-based ages whereby individuals who have the same α-age share the same characteristic (Sanderson & Scherbov, 2016). We used a characteristic-based age approach introduced by Sanderson and Scherbov (2013) to identify which age should be considered 'old'. The original model was developed to compute and compare α-ages based on four characteristics, including chronological age, remaining life expectancy, mortality rate, and proportion of adult person-years lived after a particular age (Sanderson & Scherbov, 2013). Recently, the model has been extended to apply to capability- and functional-based health indicators, such as grip strength and walking speed (Sanderson et al., 2016; Weber, 2016).

The computation of α-ages requires the specification of the index (r) and standard (s) schedules. Here, we selected the characteristic schedules of individuals with a less than primary education as the reference standard schedules (s) and the characteristic schedules of those who had completed primary and beyond-primary education as the index schedules. Then, we selected a chronological age (a) in the *r* schedule and determined the corresponding level of the characteristic in the *s* schedule. By equating the levels of each characteristic and solving the equation, we were able to obtain α-ages based on principal cognitive function for individuals with a completed primary education as follows:

$$\alpha_{\text{primary}} = \text{a} + \frac{\beta_3}{\beta_1} \qquad (2)$$

And for those with a beyond-primary education:

$$\alpha_{\text{beyondprimary}} = \text{a} + \frac{\beta_4}{\beta_1} \qquad (3)$$

In equations 2 and 3, 'a' represents the reference age, which is the age of those with a lower than primary education. The α-ages generated from the above equations can be interpreted as the respective ages at which those with higher levels of education would have similar cognitive performance levels to those with a less than primary education.

All analyzes and figures were carried out and produced by STATA version 13. Sampling weights provided along with the dataset were applied for all descriptive statistics, and regression analyzes were carried out to ensure all estimates were nationally representative.

Results

Education between men and women aged at least 60 years was dissimilar, as was their income level, as presented in Table 1. The average age in the sample, regardless of sex, was 68 years. The principal cognitive function score was 6.4 for men and approximately 6.2 for women. Fewer women (12%) achieved a higher than compulsory level of education than men (23%).

Table 1: Descriptive summary of analytic variables, older men and women in Thailand

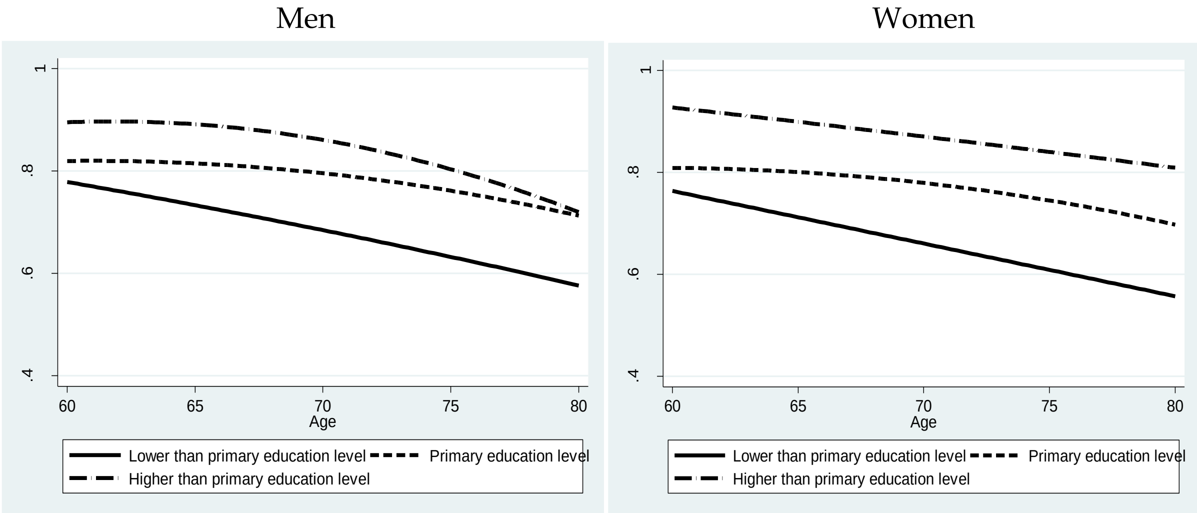
Variable	Men	Women
PCI (mean, SD)	6.4 (1.4)	6.2 (1.5)
Age (mean, SD)	68.5 (5.6)	68.8 (5.7)
Education (%)		
Lower than primary education	11.8	18.6
Primary education	65.3	69.2
Higher than primary education	22.9	12.3
Unweighted sample	2,611	3,690

Source: PCWAS, 2016

Figure 1 shows the trajectory of cognitive ageing as a function of age. The average cognitive function score among men was related to educational achievement. Those with a lower than primary education and those with a beyond-primary education showed a difference in scores across ages. The difference between men with a primary level of education and with a beyond-primary level education was especially evident at age 60, but then dropped until the gap closed by age 80 years.

The education gradient was present among women as well. However, those with a beyond-primary education level maintained a similar level of advantage in terms of average cognitive function score from ages 60 to 80.

Figure 1: Age trajectory of principal cognitive performance by age and by education level of older men and women



Source: PCWAS, 2016

The results of the regression model for the characteristics approach are presented in Table 2. Age and its quadratic form were observed to be statistically significant for both later-life men and later-life women. Increased levels of educational attainment were also positively associated with higher cognitive function scores. The coefficients for the female sample were found to have higher values than the male sample.

Table 2: Results from multiple linear regression for older person's principal cognitive performance

Variable	Male		Female	
	Coefficient	SE	Coefficient	SE
Age	0.310*	0.126	0.189*	0.103
Age^2	-0.003**	0.001	-0.002*	0.001
Education (ref=Lower than primary)				
Completed primary education	0.755***	0.165	0.856***	0.113
Higher than primary education	1.264***	0.171	1.661***	0.120
R^2	0.130		0.153	

*Note: Significance levels: * p ≤ 0.05; ** p ≤ 0.01; *** p ≤ 0.001.*
Source: PCWAS, 2016

Associating ages according to cognitive function scores is one of the strengths of the characteristics approach. The lowest educational attainment was considered the base from which a hypothesised advantage relative to those with increasing educational attainment could be assessed (Table 3). This is a means to depict the delay in cognitive ageing among those with higher education levels compared with the other categories. For both sexes, an overall increasing advantage existed in cognitive ageing with increasing levels of educational attainment.

For men, the level of cognitive performance among those aged 60 years with low education was similar to that of those at 67 years with a primary level education and 68 years with a beyond-primary level education. As age increased, the differences were observed to lessen, but the advantage of those with a beyond-primary level of education remained apparent. By 80 years of age, men with a lower than primary education had around a three-year disadvantage in cognitive ageing compared with those with increased levels of education.

A similar pattern of decreasing differences was found for women with primary and beyond-primary education levels, though this was lower in magnitude than for men. For women aged 60 years with the lowest educational attainment, the associated age with a primary education was 67 years, and almost 69 years for those with a beyond-primary education. At age 80 years, the age differences of women with a lower than primary education compared to those with a primary and beyond-primary level education were around four and five years, respectively.

Table 3: α-ages of principal cognitive performance for older men and women by education level

Reference age (Lower than primary education)	Men		Women	
	Completed primary education	Beyond primary education	Completed primary education	Beyond primary education
60	67.2	68.2	67.4	69.0
65	71.0	72.1	71.5	73.1
70	74.9	76.0	75.6	77.2
75	78.8	79.9	79.7	81.3
80	82.6	83.8	83.8	85.4

Source: PCWAS, 2016

Discussion

This study found that education levels were associated with variations in the speed of cognitive ageing. The effect of education has been suggested to be due to better health behaviour or access to healthcare in general (Kye, 2016). This finding of differentials by education is consistent with the cognitive reserve framework (Stern, 2002; Zahodne, Stern & Manly, 2015), in which people with higher levels of education mentally process tasks more efficiently through life, delaying cognitive ageing and even impairment.

In this study, cognitive functioning decline varied greatly between sexes. This is a similar result to that of a study in Latin America and the Caribbean, where differences were found from early life to advanced ages (Maurer, 2011), and which may have been brought about by biological and social factors. Biological effects have been suggested in the literature to be due to chromosomal and hormonal factors (Mielke, Vemuri & Rocca, 2014; Petersen et al., 2010). With regard to the social aspects of cognitive decline, the benefit of a beyond-primary level of education, as observed in this study, is greater among women. This is assumed in the theory of resource substitution, which states that a lack of one resource is compensated for by another (Ross & Mirowsky, 2010). In the current context, as women have fewer resources with regard to income and societal power in the Thai setting, the effect of education is magnified.

In relation to the effects of education on the level of performance of cognitive tasks, the possibility has been explored that tests of cognition may be influenced by the base capacity of those with no or low levels of education. Examples of studies testing the applicability of cognitive assessments include the MoCA in the context of Colombia (Gómez, Zunzunegui, Lord, Alvarado & García, 2013) and the MMSE for Korea (Kim, Won, Kim & Choi, 2013). The study in Colombia observed a high reliability of the MoCA among people with lower education levels, but differences were observable and dependent on the level of ability to read and write (Gómez et al., 2013). A study of older people in Korea found that having respondents with a lower education level mentally calculate 40 minus 4 resulted in a higher correlation with the correctness of responses than the usual 100 minus 7 serial computation (Kim et al., 2013). In the PCWAS, this was addressed through the framing of the numeracy section. Instead of proposing a hypothetical 100 minus 7 calculation, the exercise was phrased in monetary terms (100 baht minus 7 baht etc.). Adapting this particular instrument is essential in determining the cultural underpinnings of a society, as has been done for other surveys in different countries (Fujiwara et al., 2010).

Conclusion

This study offers insights into the study of ageing, using a novel method to understand an aspect of later-life Thais' cognitive performance. Population ageing must be viewed as varying among people within a population. This approach to understanding later-life adults may be helpful in directing health programs towards those who may need more support and care. Educational attainment, as observed in this study and in agreement with the general literature, shows gradients of cognitive performance decline. This is important to note in determining human capital and the functional capacity of people given their age.

Ethical Statement

This research has been approved by the IRB of Chulalongkorn University (COA No. 095/2559).

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