Projection and determinants of cognitive ability among older persons in Thailand:Role of education

Mr. Paolo Miguel Vicerra

A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy in Demography
Common Course
COLLEGE OF POPULATION STUDIES
Chulalongkorn University
Academic Year 2019

การคาดประมาณและตัวแปรกำหนดการสูงอายุทางพุทธิปัญญาของผู้สูงอายุในประเทศไทยบทบาทของการศึกษา

นายเปาโล มิเกล วิเซอรา

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรดุษฎีบัณฑิต
สาขาวิชาประชากรศาสตร์ ไม่สังกัดภาควิชา/เทียบเท่า
วิทยาลัยประชากรศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2562

Thesis Title	Projection and determinants of cognitive ability among older persons in Thailand:Role of education
By	Mr. Paolo Miguel Vicerra
Field of Study	Demography
Thesis Advisor	Associate Professor WIRAPORN POTHISIRI, Ph.D.

Accepted by the COLLEGE OF POPULATION STUDIES, Chulalongkorn University in Partial Fulfillment of the Requirement for the Doctor of Philosophy

..... Dean of the COLLEGE OF POPULATION STUDIES
(Professor VIPAN PRACHUABMOH, Ph.D.)

DISSERTATION COMMITTEE

..... Chairman
(Professor PUNGPOND RUKUMNUAYKIT, Ph.D.)
..... Thesis Advisor
(Associate Professor WIRAPORN POTHISIRI, Ph.D.)
..... Examiner
(Assistant Professor PATAPORN SUKONTAMARN, Ph.D.)
..... Examiner
(Assistant Professor RUKCHANOK KARCHARNUBARN, Ph.D.)
..... External Examiner
(Professor Wichai Aekplakorn, M.D., Ph.D.)

เปาโล มิเกล วิเซอรา : การคาดประมาณและตัวแปรกำหนดการสูงอายุทางพุทธิปัญญาของผู้สูงอายุในประเทศไทยบทบาทของการศึกษา. (Projection and determinants of cognitive ability among older persons in Thailand:Role of education) อ.ที่ปรึกษาหลัก : วิราภรณ์ โพธิศิริ

ในปี 2563 ประเทศไทยมีประชากรอายุ 60 ปีขึ้นไปประมาณร้อยละ 60 และต่อมาในปี 2583 สัดส่วนประชากรสูงอายุเพิ่มขึ้นเป็นร้อยละ 35 ผู้สูงอายุมีแนวโน้มมีอายุคาดหมายเฉลี่ยเพิ่มสูงขึ้น แต่มีโอกาสที่จะมีภาวะทุพพลภาพเพิ่มขึ้นตามอายุที่ยืนยาวมากขึ้น ข้อค้นพบในปัจจุบันความชุกของความบกพร่องด้านการทำงานของสมองเพิ่มขึ้นในทุกสังคม รวมทั้งประเทศไทย

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาบทบาทของการศึกษาต่อพุทธิปัญญาของผู้สูงอายุในประเทศไทย โดยใช้ข้อมูลจากการสำรวจระดับชาติในปี 2559 โครงการการเปลี่ยนแปลงทางประชากรและอยู่ดีมีสุขในบริบทสังคมสูงวัย และใช้การวิเคราะห์พหุตัวแปรหลากหลายวิธีในการนำเสนออิทธิพลของการศึกษาต่อความสามารถด้านพุทธิปัญญา

ผลการศึกษาที่ 1 พบว่า ความสัมพันธ์ระหว่างสถานะสุขภาพ รูปแบบการอยู่อาศัย และการมีส่วนร่วมทางสังคมกับความสามารถด้านพุทธิปัญญามีความแตกต่างระหว่างเพศชายหญิง ส่วนอิทธิพลของอายุ การศึกษา และรายได้ต่อความสามารถด้านพุทธิปัญญาไม่แตกต่างระหว่างเพศชายหญิงแต่อย่างใด ผลการศึกษาที่ 2 การวิเคราะห์อัตราความชุกของการเกิดโรคจำแนกตามอายุ เพศ และการศึกษา พบว่า อัตราความชุกของการเกิดโรคมีแนวโน้มลดลงอย่างมีนัยสำคัญเมื่อเพิ่มตัวแปรการศึกษาเข้ามาในแบบจำลอง ในขณะที่ระดับการศึกษามีความสัมพันธ์แบบแปรผกผันกันการมีข้อจำกัดในการเคลื่อนไหวและภาวะการพึ่งพิงด้านอายุ ผลการศึกษาสุดท้ายเป็นการวิเคราะห์ความแตกต่างของความเร็วของการสูงอายุทางพุทธิปัญญาจำแนกตามระดับการศึกษา พบว่า ผู้สูงอายุที่มีการศึกษาสูงกว่าประถมศึกษาขึ้นไปมีความสามารถทางพุทธิปัญญาสูงกว่าผู้สูงอายุที่มีการศึกษาต่ำกว่าประถมศึกษาประมาณ 10 ปี ไม่ว่าจะเป็นผู้สูงอายุชายหรือหญิง

สาขาวิชา	ประชากรศาสตร์	ลายมือชื่อนิสิต .....
ปีการศึกษา	2562	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

6086956951 : MAJOR DEMOGRAPHY
KEYWORD: Cognitive ageing, Ageing in Thailand, Characteristics approach, Education and population

Paolo Miguel Vicerra : Projection and determinants of cognitive ability among older persons in Thailand:Role of education. Advisor: Assoc. Prof. WIRAPORN POTHISIRI, Ph.D.

This thesis examines the role of education on cognitive ability among the older population of Thailand. The nationally-representative data primarily utilised in this thesis is 2016 Population Change and Well-being in the Context of Aging Society. Other datasets had been used in selected themes within this thesis. Multiple analytic approaches had been applied to this study to show various effects of education gradients on cognitive functioning.

In the first study, education and other covariates including income, health status, living arrangement, and social participation among others had been analysed by gender to test if the significant factors would be similar. It was observed that education and income are the only determinants consistently associated among genders with cognition. For the second study, the prevalence of ill health including lower cognitive performance were estimated. Two sets of models were created for the said estimations with one controlling for age and sex and the other controlling for age, sex, and education levels. These estimates were then applied to current and projected populations and what was observed was the prevalence of ill health was significantly lower when education level is integrated into the models. The functional limitations and dependency of older persons is lower when older people have higher levels of education. In the final study within this thesis, the characteristics approach is used to analyse the differences on the speed of cognitive ageing by education levels. The general observation among genders is that there is about a 10-year advantage in cognitive performance for those with higher than primary level of education compared with those who have lower than primary level. Comparing the trajectory of cognitive ageing, women with primary education and higher than primary education levels experience slower declines as they age compared with men with the same education levels.

Field of Study:	Demography	Student's Signature .....
Academic Year:	2019	Advisor's Signature .....

ACKNOWLEDGEMENTS

My deepest gratitude to:

Dr. Wiraporn Pothisiri for guiding me through my graduate studies. I cannot express how grateful I am that you are my supervisor. I have learned so much from you and the opportunities you have opened for me have been unbelievable.

Dr. Sergei Scherbov for being co-supervisor to this thesis. His innovations in the approach to the study of ageing have been formative and I learned much from him while I was in IIASA for the ReAging Project supported by the ERC.

Dr. Pungpond Rukumnuaykit, Dr. Pataporn Sukontamarn, and Dr. Rukchanok Karcharnubarn for being panel members and providing your insights for this thesis.

Dr. Wichai Aekplakorn. Thank you for agreeing to become a panel member and sharing your expertise.

Dr. Vipan Prachuabmoh and the professors of the College of Population Studies for teaching me ever since my M.A. studies.

Dr. Wolfgang Lutz. I am grateful that you were my co-supervisor for my YSSP research. Your support made my involvement with the Wittgenstein Centre for Demography and Global Human Capital possible.

Dr. Warren Sanderson for providing his insights in my research.

The College of Population Studies for providing the John Knodel Fellowship. My doctoral studies would not have been possible without the support initiated by Dr. John Knodel.

Mr. Visanu, Ms. Wanwadee, Ms. Bussarin, and all the staff members of CPS for the assistance you provided without which I could not have done anything.

Thananon and Orawan for being helpful senior colleagues in CPS.

Arda, Guillaume, Anna, Samir, Anne, Raya, Erich, Claudia, Jeof, Katja, Stefanie and the whole World Population Program of IIASA and the rest of the Wittgenstein Center. Everyone was always ready to help out and they made me feel welcome from the beginning.

Elke. für alles

Linda. Vamos para Viena em breve.

The following awesome friends who are dear to me: Matthew for being my trusted best friend. Nicolas for putting up with my pathetic running. And Talita, Alex, Rory, Asya, Paul, Hélène for the fun.

The YSSP 2019 people. The testament that soon-to-be doctors can be insanely amazing.

Karryl and Julius. I'm glad you're with me even in hard times.

Jem. The guy who'll always be there.

Joey, Karlo, Khent, and Bryan. We survived 2020 together.

My family: Edwin, Pilar, Pauline, Patrick, Jon, Anahí, Andrés. I have spent so little time with you but it's been important for me to know you are there to support me in my decisions.

Paolo Miguel Vicerra

TABLE OF CONTENTS

Page

List of Tables

List of Figures

Acronyms

OP – Older persons

SES – Socioeconomic status

MCI – Mild cognitive impairment

AD – Alzheimer's disease

ADL – Activities of daily living

IADL – Instrumental activities of daily living

RLE – Remaining life expectancy

DALY – Disability-adjusted life years

NCD – Non-communicable diseases

OADR – Old age dependency ratio

ADDR – Adult disability dependency ratio

CADR – Cognition-adjusted dependency ratio

UN – United Nations

WHO – World Health Organization

ISCED97 – International Standard Classification of Education 1997

EA – Enumeration areas

PCWAS – Population Change and Well-being in the Context of an Ageing Society

NHES – National Health Examination Survey

SOPT – Survey of Older Persons in Thailand

SOEP – German Socio-economic Panel

ELSA – English Longitudinal Study of Ageing

SHARE – Survey of Health, Ageing and Retirement in Europe

SAGE – Study on global AGEing and adult health

HRS – Health and Retirement Study

JSTAR – Japanese Study of Ageing and Retirement

SABE - *Salud, Bienestar y Envejecimento* (Health, Well-being and Ageing)

MMSE – Mini-Mental State Examination

MoCA – Montreal Cognitive Assessment

STMS – Short Test of Mental Status

Chapter 1: Introduction

1.1. Introduction

Presented in this chapter is the supposition to how this thesis on the cognitive ageing of the older population in Thailand was conceptualised. Firstly, a background is provided regarding global background on ageing and cognitive health (1.2). The succeeding section presents the rationale of the study (1.3) and lastly, the structure of the thesis (1.4) is presented.

1.2. Global background

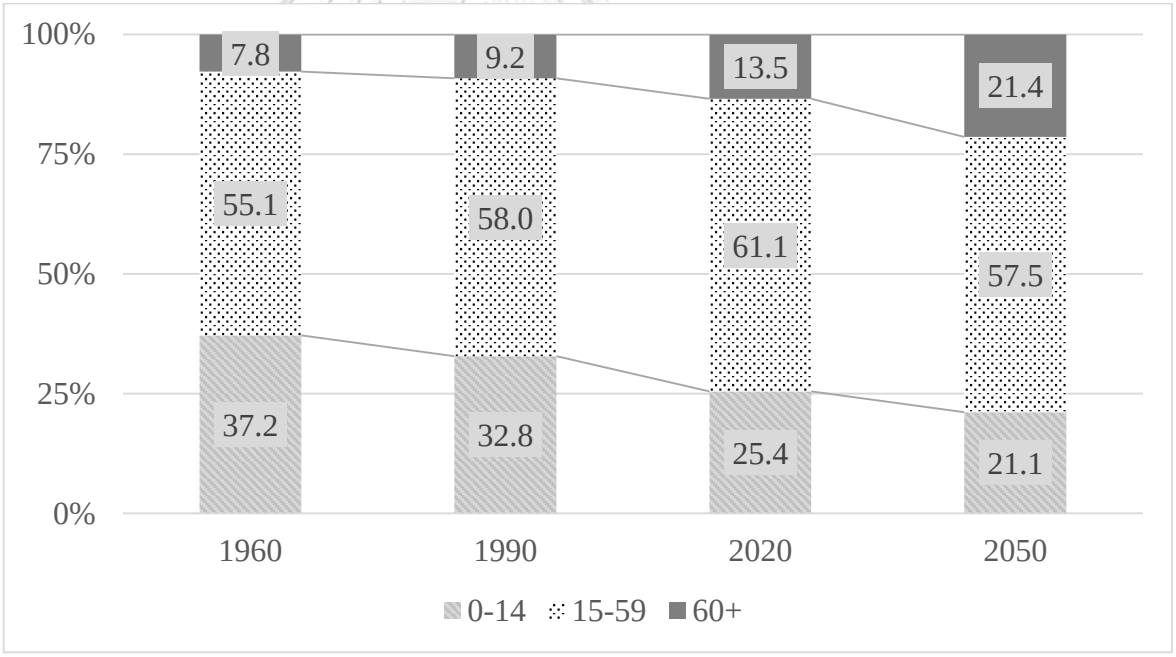
The population of the world is ageing. The number of people aged at least 60 years, or the older persons (OP), increased to a certain level relative to the total population of a country. The health situation in ageing societies had also changed particularly in terms of cognitive health. The situation on ageing, cognitive health status among the older population, and the determinants affecting the process of cognitive decline are presented in this section.

1.2.1. Ageing situation in the global context

According to population figures from the United Nations (2019), the young population aged 0 to 14 years in 1960 comprised 37 per cent of the world population while the older population constituted about 8 per cent (Figure 1.1). In 2050, the

proportion of young population decreases to about 21 per cent of the total global population and the older population would increase to 21 per cent. A number of factors have affected the global population structure including the proliferation of family planning policies, modernisation of contraceptive and health technologies, and the general improvement in economic development of societies (Ezeh, Bongaarts, & Mberu, 2012). Life expectancies among countries had also improved over recent decades due to developments in health technologies and interventions (Crimmins & Beltrán-Sánchez, 2010; Jagger et al., 2008) .

Figure 1. 1: Percentage distribution of world population by age groups, 1960-2050.



Source of data: World Population Prospect, 2019. (Accessed on 15 March 2020)
Note: Results shown are based on the medium fertility variant that assumes the total fertility rate (TFR) will decline continuously from 5.02 in 1960-1965 to 2.21 by 2045-50.

The unprecedented shift in population structure has posed challenges to societies (Beard & Bloom, 2015; Bloom et al., 2015). The share of working-age population is diminishing and this is a challenge to the labour needs of societies which should reconsider policies to address decline in economic output (Bloom, Börsch-Supan, McGee, & Seike, 2012). Another implication to the lower share of working-age adults is its impact on the current state of pension systems where younger adults contribute to the income of older people (Bloom et al., 2015). Countries in Europe have various existing pension systems and each had to accommodate their experience of population ageing such as reconsidering provisions regarding early retirement as they would provide longer to members longer (Heijdra & Romp, 2009). Developing countries, including Thailand, can have a different issue as most of the older persons had been in the informal economy and therefore are not members of the pension system (Suwanrada, 2008).

Another challenge observed among ageing populations is the health status of OP (Beard & Bloom, 2015). People in their advanced ages currently have longer life expectancies than in recent decades (Sanderson & Scherbov, 2007). As exemplified by Beard et. al. (2016), a child recently born in Brazil and Myanmar have life expectancies 20 years longer than those born five decades ago. Living longer is different from ageing healthily such that the older population may bear functional disabilities impeding their capacity for employment and self-care (Chatterji, Byles, Cutler, Seeman, & Verdes, 2015; Crimmins & Beltrán-Sánchez, 2010). Studies on healthy ageing identifies differences in the prevalence of physical, mental, and cognitive health dimensions (Chatterji et al., 2015). A great number of healthy ageing studies are on physical health and the presence of non-communicable diseases (NCD)

as the data is accessible from medical records, surveys and clinical studies (Reiner, Niermann, Jekauc, & Woll, 2013; Vos et al., 2015; Warburton, Nicol, & Bredin, 2006). Cognitive function and mental health are relatively overlooked (Degenhardt, Whiteford, Hall, & Vos, 2009; Prince et al., 2007; World Bank, 1994). The mental and cognitive dimensions of health of older persons tend to have sparse data even among high-income countries which lead to gaps in the understanding of overall health (Chatterji et al., 2015).

Cognition has a crucial role toward the independent and productive functioning in each stage of life. It develops in infancy in conjunction with sensorimotor and social skills (Nelson, 1996); and continues to youth and middle-age adulthood where the peak robustness is manifested in terms of reasoning, numeracy, and language fluency (Craik & Bialystok, 2006). Cognitive performance decline is generally observed at later adulthood (Grady & Craik, 2000).

Dementia is the general term that encompasses symptoms of cognitive decline (World Health Organization, 2012). In 2015, the number of older persons with dementia worldwide was at 47 million persons or five per cent of the total older population (World Health Organization, 2015). It is estimated that 60 per cent those who live with dementia are in low- and middle-income countries. In a previous report by the WHO (2012), dementia prevalence among older people in Southeast Asia is estimated at 6.5 per cent; 8.5 per cent in Latin America; and 2 per cent in sub-Saharan African Regions. Alzheimer's disease (AD) is the most common type of dementia which is described as a debilitating disease (World Health Organization, 2006). In 2006, about 13 million older persons with AD were in Asia whereby it was about half

of the total number of older population in the world with AD (Brookmeyer, Johnson, Ziegler-Graham, & Arrighi, 2007).

The changing landscape of population structures that is moving toward ageing would have an impact on the estimated prevalence of cognitive diseases such as dementia across regions of the world. It is important to determine the factors contributing to the development of this disease among OP.

1.2.2. Causes of cognitive decline

1.2.2.1. Natural ageing

Gradual waning in functioning along with the probability of the presence of debilitating diseases are observed for the older population. Age has the strongest association with the onset of ill cognitive health particularly dementia and AD (World Health Organization, 2017a). The human brain naturally degenerates and the process tends to become more conspicuous in advanced ages (Ferrer, 2012). Particular to this process is the prevalence of other diseases that are also related with age, such as Parkinson's disease among others, which further conflates the natural speed of cognitive decline (Aarsland et al., 2007; Ferrer, 2012). Although it is evident that health generally declines through age, other attributes of individuals may affect this process differently. This is explored in the succeeding section and highlights education as a central social factor.

1.2.2.2. Education and cognitive health

As social and environmental contexts are important in the health status of older people, social disparities may affect their health (Kleinman et al., 2016; Thanakwang & Soonthorndhada, 2011). It was observed that personal histories of individuals may manifest effects in older ages; such as the case of experiencing poverty during younger ages exhibit negative outcomes in cognitive performance at older ages (McEwen & Gianaros, 2010a). There are varied contentions on how the quality of the

person's schooling may also have an impact on how his cognitive health status manifests in later years (Skirbekk, Loichinger, & Weber, 2012). One such argument is a socio-biological notion through the improved development of the cognitive reserve of the brain for people with better education (Stern, 2002).

1.2.3. Further examination of education and cognitive health

Novel approaches have been formulated in studying the nexus of social characteristics and cognition among older persons (Sanderson & Scherbov, 2016). Reliance on conventional methods are limited to the perspective they can offer to the study of health and ageing such that they do not accommodate the changes that have occurred in recent decades. This is exemplified through the inclusion of culturally grounded factors to the population (Bongaarts & Zimmer, 2002; Paú, Ribeiro, & Santos, 2010).

The studies available regarding the effects of social characteristics on cognitive ageing pertain to economically-developed societies (Adam, Bay, Bonsang, Germain, & Perelman, 2006; Liang Feng et al., 2017; Mazzuco, Meggiolaro, Ongaro, & Toffolutti, 2017). The findings in those studies are important in providing insights to health and ageing in general but such observations are also influenced by the setting of the older population. Education as a factor is a central theme in gaining knowledge about the development of ageing population in specific contexts. Having studies that are representative of a particular setting is judicious in order to offer perspective on a complex issue such as cognitive ageing.

It is important to explore how education affects cognitive health as it had been observed to have strong effect on the prevalence of NCDs (Cutler & Lleras-Muney, 2006; KC & Lentzner, 2010), Through the current developments in analytic techniques in exploring education and health such as the characteristics approach (Sanderson & Scherbov, 2014), it is possible to delve further into how this relationship is manifested whether in the setting of developed or developing societies that have populations that are ageing.

1.3. Rationale

This thesis reflects my continuous effort to understand the causes and consequences cognitive ageing in the context in the context of a developing country in an Asian setting. Compared with the current state of this research, there has been deviation from what I had proposed to study. I was persuaded to employ novel approaches on understanding cognitive health among older adults after reading the array of studies and investigating the data regarding demographic and socioeconomic correlates of cognitive performance in subsequent years of my study programme. This particular approach is the ‘characteristics approach’ established by Sanderson and Scherbov (2007, 2008, 2010, 2016). This is not limited to being a method of analysis but the characteristics approach also inherently considers a shift in perspective. As a method of analysis, it is able to show the impact of education on cognitive ageing by considering the older population as a heterogeneous group whereby individuals age at different speeds. As a perspective, this can challenge the concept that older people are ‘dependent’. These aspects of the analytic approach can be applied to current and

population data to determine the prevalence of ill cognitive health status therefore be able to prepare for the probable needs of older persons in terms of care.

The aim of this thesis is to create a thematic understanding of cognitive ageing in Thailand through differentiated social characteristics of the older population. As a human capital dimension, education is used as the main factor for the analytical designs regarding the following primary themes undertaken in this thesis:

i. What are the factors that are probably associated with improved cognitive performance in spite of the ageing process?
ii. How can the needs of older people in the future be estimated with regard to their level of cognitive functioning?
iii. Given the varying characteristics of older individuals, how different is the manifestation of cognitive decline between them?

In the following sub-sections, we will describe why Thailand is an appropriate setting for this study are presented including the background information on population ageing in Thailand (1.3.1), prevalence of cognitive diseases (1.3.2), the education system (1.3.3), the initiatives of the government of Thailand with respect to cognitive health status (1.3.4), and a summary (1.3.5) integrating the rationale for performing a study on cognitive ageing in Thailand.

1.3.1. Ageing in Thailand

According to Knodel and Chayovan (2008), population ageing had been developing in Thailand since 1980 whereby the growth rate of the older population was 4.4 and the total population growth rate was 1.64. According to the UN World Population Prospect (2019), Thailand's older population comprised about 5 per cent of the total population in 1960 and had continued to increase from that period. This trend in the proportion of older persons in Thailand will continue to increase according to projections (Table 1.1).

Table 1. 1: Population projections of Thailand, 2020 to 2100

Age groups	**2020**	**2040**	**2060**	**2080**	**2100**
0-14	16.6	12.9	13.9	13.9	14.3
15-59	64.2	54.0	41.6	39.1	39.2
60+	19.2	33.1	44.4	47.0	46.4
Total (in thousands)	69800	69008	53587	47030	40728

Source: World Population Prospect 2019 (Accessed on 15 March 2020)
Results shown are based on the medium fertility variant that assumes TFR will decline to 1.42 between 2025-2030 and then increase to 1.51 by 2045-50.

The proportions of the younger age and working age groups are projected to decline between 2020 and 2080 from about 17 to 14 per cent and 64 to 39 per cent respectively. This is consistent with the substantial increase in the proportion of older persons from 19 to 47 per cent in the next 60 years. The proportion of the younger population may increase in 2100 while a decrease would occur for the older

population. Although this is the scenario, the proportion of the working-age adults in that year would remain in a similar level as it were in 2080.

1.3.2. Prevalence of cognitive disease in Thailand

The increase in the number of older people raises concerns on healthcare. The risks of developing chronic and debilitating diseases increase for the population with advanced ages (World Health Organization, 2017b). This particular concern has been noted by Gray (2006) as it will affect health system financing across many countries including Thailand. This is exemplified by the estimates of disability-adjusted life years (DALY's) between countries (Table 1.2). The burden of diseases increases among those in more advanced ages. Another notable matter is the contribution of cognitive impairment-related diseases as AD can have higher impact than diabetes mellitus among those aged at least 70 years.

Table 1. 2: Estimates of DALYs per 1,000 population lost to diseases among select East and Southeast Asian countries, 2015

	Diabetes mellitus		**AD and other dementias**		**Cardiovascular disease**	
	60 - 69	**70+**	**60 - 69**	**70+**	**60 - 69**	**70+**
Cambodia	20.4	27.2	9.8	58.3	210.7	512.6
China	85.2	91.1	9.7	59.4	329.9	642.7
Japan	39	53.2	9.1	56.8	253.6	581.3
Singapore	7.7	14.4	1.6	18.3	81	177.7
Thailand	44.3	58.4	11	62.8	130	275.9

Source: Estimates from Loichinger & Pothisiri (2018)based on WHO (2016)

1.3.3. The development of the education system of Thailand

A traditional form of education had existed in the Kingdom where the content is monastic (Pacharapimon & Gamage, 2010). Young men were trained in monasteries where they learned Thai and Pali. Aside from grammar, students were also taught arts, medicine, and arithmetic among others. The first phase of reform of Thai education is attributed to the reign of King Chulalongkorn (King Rama V) (Fry & Bi, 2013). Modernisation was the goal of the upheaval in how education was conceptualised and delivered (Wyatt, 1969). This modernisation was to maintain the Thai identity among the people while being capable of engaging with the world. Bilingual education had become a feature of the curriculum where the Thai language was used half of a day and English in the other half (Fry & Bi, 2013). King Chulalongkorn had been adept at travelling and learning from many countries which made him aware of the need of the people for skills in trade and commerce (Wyatt, 1969). The central challenge within this phase of the education reform was the issue of delivery. As noted by Wyatt (1969), there were concerns regarding the concentration of resources in Bangkok. Remote areas remained to have less accessibility to education.

The restructuring of education administration by the government was done in the second phase of transformation (Charnvit, 2000; Fry & Bi, 2013). The aim was to establish lower secondary schools in large districts and upper secondary schools in provinces (Nitungkorn, 1988). Apart from the brick-and-mortar approach to improve the access of young people to the education system, the structure of schooling was also done through the establishment of the 6-3-3 system. Compulsory basic education

was raised from four years to six years. Secondary school was increased from five to six years; three years for lower secondary school and another three for upper secondary.

The third phase is indicated to be around 1997 when there was the Asian financial crisis (Fry & Bi, 2013). Education reform became part of the path to economic recovery which had led to the current policies of decentralisation, student-centred learning, and the promotion of technology in education. The initiatives were presented by the Office of the National Education Commission (2002) which included the expansion of free education, self-governance among higher education institutions, and the promotion of lifelong learning among other provisions. By 2009, this education policy initiative of the government led to the establishment of a 9-year compulsory education and that 15 years of education was guaranteed to be free (Fry & Bi, 2013). Greater access to preschool education was developed and primary education was near-universal. The issues that remained and are continually being reviewed are access to secondary education and the general quality of education as students' performance in Thailand lags behind other countries in subject areas including mathematics, science, and English (Fry & Bi, 2013; Natthapoj, 2011).

Given the history of developments the education system of Thailand had undergone, the distribution of the population by education level in recent decades is presented in Table 1.3. The proportion of OP with lower than primary level of education had decreased from 1986 to 2014. The increase in the proportion of OP with primary level of education has been more stark compared with the increase of the older population with above primary level of education.

Table 1. 3. Percentage distribution of older persons in Thailand by education attainment level, 1986-2014

	1986a	1994	2002	2007	2016b
Lower than primary	72.2	42.5	29	23.3	14.4
Primary	22.3	50.5	61.9	68.3	68.8
Above primary	5.6	7.1	9.1	8.4	16.8

Sources: [a1986-2007] figures were lifted from Knodel and Pothisiri (2015, p.7) which was based on the 1986 Survey of Socio-economic Consequences of Ageing of the Population in Thailand; and the 1994, 2002, and 2007 Survey of Older Persons in Thailand

[b2016] PCWAS

Sources: [a]1986-2007 figures were from Knodel and Pothisiri (2015) which was based on the 1986 Survey of Socio-economic Consequences of Ageing of the Population in Thailand; and the 1994, 2002, 2007, 2011, and 2014 Survey of Older Persons in Thailand

[b]2016 PCWAS

1.3.4. Initiatives of the government of Thailand with respect to cognitive health status

Due to the probability of leading a life in disability increasing with age, successful or active ageing has been encouraged by the WHO (2002). This involves reaching older ages while maintaining as much capability of individuals to engage in activities. The government of Thailand recognises this need because of the situation the society is experiencing and will continue to experience. Many policies and programmes have been developed to cater to the needs of those in this age group. The Older Person Act of B.E. 2546 for one provides for basic benefits in medical and health services, transportation privileges, vocational training, and social participation

among others (Jitapunkul & Wivatvanit, 2009). Although this type of policy action is not intended to address all problems but be a remedy to some of the issues arising.

Programmes are needed as well and there had been various, scattered initiatives thus far. Recently, the "4 Smart" was launched which involve "Smart Walk, Smart Sleep, Smart Eat, and Smart Brain" (Department of Health - Ministry of Public Health, 2018). Smart Walk is the promotion of having a body that is not prone to falls and one that can exercise regularly. Smart Sleep is having the capability to sleep for up to eight hours. Smart Eat is being able to consume food that fit the nutritional guidelines and being able to do so with a complete set of teeth. Finally, Smart Brain having good mental and emotional health. This is an important aspect because it recognises both the physical health need as well as the social facet in an older person's life. It is encouraged here to give attention to physical health dimension whereby older persons are discouraged from detrimental health behaviours particularly smoking and drinking. The other aspect to Smart Brain is social participation to prevent negative emotional and cognitive repercussions for those who are isolated from society.

There had been other initiatives particularly on cognitive health including the dementia screening in primary care settings. This is a positive development but, there had been caution in the utilisation of such programmes (Boustani, 2013). The metrics and method of assessment of dementia has to be particular and appropriate in this setting. In the case of Thailand, metrics of assessment have been tested over the years and are continuing to be developed (Senanarong et al., 2001; Thaneerat et al., 2017; Trongsakul, Lambert, Clark, Wongpakaran, & Cross, 2015).

Given the undertaking of the government to be committal to gathering data and studies on the cognitive health of the older population, it is apt to contextualise the dynamics between social characteristics and health status. Doing so would lead to the possibility that policies can become more responsive to the needs of the older people. In the case of the current study, the exploration of the relationship between education and cognitive health is performed.

1.3.5. Summary

Thailand has an ageing population and studies are available with regard to the health status. There are many thematic areas of study yet to be explored particularly cognitive functioning and performance. Furthermore, this is explored with educational attainment as the focus as this has been the social factor that is significantly associated with health. This theme has presence in the literature concerning societies that are economically developed and therefore exploring it from the perspective of an Asian developing country is important.

1.4. Structure of the thesis

The current thesis consists of six chapters including this introductory chapter. In this present chapter (1), the global context of population ageing and cognitive health status were presented. The rationale of the thesis was also presented by describing the older population together with the development of the education system of Thailand to understand the context of the education attainment level of the current older

population. Chapter 2 is a review of the literature covering the pertinent themes of this research undertaking. Chapters 3,4, and 5 are substantive chapters that include respective results and discussion parts. A dedicated chapter on methods of analyses is not presented herein since detailed research methods have already been provided in each of these chapters. Each of the three chapters represent a different aspect of understanding cognitive ageing while maintaining cohesiveness.

In Chapter 3, the association of education level with cognitive performance among OP in Thailand is tested along with other demographic, socioeconomic, health-related, and social engagement factors. Upon observing that education is indeed associated with the outcome together with income and age for both older men and women, these covariates were utilised for the two succeeding chapters when applicable.

A population-level perspective to cognition of advanced-aged adults was observed in Chapter 4. The prevalence of ill-cognitive functioning by education level is estimated in current and projected populations. Income in this regard was excluded from the analysis because of limitations in data. Specifically, population projections were unavailable that accounted for this human capital factor.

In Chapter 5, the impact of education and income gradients on the cognitive ageing process were compared. The characteristics approach is performed whereby differences in the trajectories or speed of cognitive ageing were estimated given the differences in social background and characteristics of older individuals.

Chapter 6, which is the final chapter, draws together the findings and discussions from chapters 3 through 5, presents the limitations of the studies within this thesis, and proposes policy recommendations and avenues for future research.

Chapter 2: Review of literature

2.1. Introduction

There are three sections in this chapter mainly: cognitive functioning and its conceptualisation and measurement (2.1), social characteristics and cognitive ability (2.2), and novel perspectives and approaches to cognitive ageing (2.3). An overall summary (2.4) to integrate the shortcomings in the literature.

In this section introduces the studies that had been done on ageing with regard to cognition and the means that it had been conceptualised and measured. Firstly, a presentation of cognitive and non-cognitive ageing theories (2.1.1). Following is the measure called principal cognitive function (2.1.2) and how this said measure can be operationalised (2.1.3).

2.1.1. Cognitive and non-cognitive ageing theories

A central aspect of ageing is the blunt decline in cognition (Anderson & Craik, 2017; Goh & Park, 2009; Park & Festini, 2017). Clinical studies use a variety of techniques to depict this including the physiological underpinning of cognition which is the neural activities and the state of the human brain itself and how it had developed until older ages (d'Esposito & Postle, 2015; McEwen & Gianaros, 2010a). Another approach is to gauge how people perform cognitive tasks (Park & Festini, 2017).

In the earlier years, the prominent cognitive ageing theory focused on speed of processing (Birren, 1965; Salthouse, 1996). The fundamental aspect of this contention is the performance of older persons' memory decline because the duration it takes to

perform memory and mental tasks is lengthier which causes delays in the performance of other cognitive tasks, i.e. remembering basic information may be sub-optimal leading to difficulties in decision making. There had been ensuing criticism of such views whereby the time taken for tasks is not the key factor but the quality of processing (Craik & Lockhart, 1972). They postulated that quality encoding is important and information that older persons consider relevant would be successfully retained and processed. This is said to be the case even if there is an overt lack of attempt to remember information but such details are recollected nonetheless. Among these cognitive theories, what is noticeable is the designation that age is the fundamental determinant of decline.

There are also other perspectives where psychological and social factors are considered and these are called non-cognitive theories (Park & Festini, 2017). There is the view that social and environmental factors are present which can influence or shape cognition and its variety of expressions (Anderson & Craik, 2017; Hedden & Gabrieli, 2004). It is recognised that lifestyle, particularly exercise and mental training, can have protective effects on cognitive health and performance (Reuter-Lorenz & Park, 2014). This is also the case for the valuation of education as a factor for cognition (Richards & Sacker, 2011). Due to cognitive health being only present in more recent representative sample studies through surveys, more studies now view social factors, especially education, as having foremost effect (Adler et al., 1994; Evans et al., 1997; Hedden & Gabrieli, 2004; Sattler, Toro, Schönknecht, & Schröder, 2012).

Studies that are clinical in nature oftentimes posit that older persons are homogenous because changes and status of cognition are physiological. Non-

cognitive theories confirm older persons have different personal characteristics therefore the experience of cognitive ageing is also different. It is then deemed important to look into these individual attributes and social factors.

2.1.2. Primary cognitive function

In physiobiological studies, cognition is not a singular process whereby there are biological specificities to it as functions such as memory are activated in different parts of the brain (Grady & Craik, 2000; Hedden & Gabrieli, 2004). The first type of memory is the short-term memory which includes the ability to perform primary cognitive tasks such as the capacity of holding a series of digits or words and having the ability to repeat it (Craik & Jennings, 1992). The second type is called the principal cognitive function or the working memory. This is where the held sequence or information undergoes additional manipulation as reciting letters backwards or even performing mental arithmetic (Tardif & Simard, 2011). Working memory is particularly distinguished in the literature because of its propensity to be much affected by age progression compared to long-term or emotionally-laden memory; even among those with Alzheimer's disease (Fleming, Kim, Doo, Maguire, & Potkin, 2003; Grady & Craik, 2000; Trott, Friedman, Ritter, Fabiani, & Snodgrass, 1999).

Expanding on principal cognitive function is important because part of this, as mentioned earlier, are numeracy and word recall. These specific tasks are more sensitive to mild cognitive impairment (Ichimura, Shimizutani, & Hashimoto, 2009). It involves the storage of information in short intervals and the manipulation of such information for specific tasks (Ma, Husain, & Bays, 2014). It is a persistent neural activity in many regions of the brain and it is also an underlying cognitive process for a range of behaviours including problem solving (d'Esposito & Postle, 2015; Ma et al., 2014). Working memory is correlated with intelligence and also becomes apparent

in terms of decline in older ages. The physical and mental factors that are postulated to affect older persons rather than younger people in terms of working memory is interference (d'Esposito & Postle, 2015; May, Hasher, & Kane, 1999). This can be an introspective interference, which is a mental noise, or an external interference whereby there is a presence of other stimuli. Older persons are more susceptible to these noises leading to a declined level of performance in such tasks.

Much of the aspects in decline of cognition may be attributable to the biological aspect but there are also behavioural aspects (Hedden & Gabrieli, 2004). There are cross-sectional studies, and to a lesser extent longitudinal studies, that determine the status of cognitive health aspect of older persons and how it may develop as they increase in age. This point is where the variability among individuals become apparent. As life experience, genetics, and general risks to pathology are present, some people may be more vulnerable to cognitive decline than others (Hedden & Gabrieli, 2004). This variability is applicable at the aggregate level where there are differences in prevalence and causality for each society. Chatterji and colleagues (2015) reviewed the status of health and disability status across countries where data is available. There are commonalities among the countries examined but mostly it is highlighted that the scenarios vary from society to society which is borne of the reason that measurements are unrefined whereby the definitions tend to have different dimensions. Also, developing countries are less represented in the literature due to lack of data. It is then important to consider the studies that have been done on which aspect of cognitive function to study, which measure to use, and which instruments to analyse.

2.1.3. Measuring cognitive function

Cognitive function has been shown to have developed and improved between populations in different periods. In a study showing German and English data comparing 50 to 90 year olds taken on 2006 and 2012, the recent cohort have been observed to perform better in cognitive tests than previous cohort (Bordone, Scherbov, & Steiber, 2015). To show this development in cognitive performance, the authors used the symbol-digit test and the animal-naming test in the German Socio-Economic Panel (SOEP). The symbol-digit test involves showing numbers with corresponding patterns and after which, only the patterns are shown and they have to be matched to the correct number. The result is based on the speed and accuracy of matching. The animal-naming test is identifying as many animals as possible. Bordone and colleagues (2015) also utilised the English Longitudinal Study of Ageing (ELSA) which contained two verbal recall tests. The first involves being read a list of ten words and after an interval, the respondent has to recall and recite them. The other test is the Letter-Cancellation Task which contains 780 randomly arranged alphabet letters in a grid of 26 rows by 30 columns and from here, respondents would have to cross out the "P' and 'W' as quickly and accurately as possible following the direction of how one reads in the English language which is across from left to right and gradually descending along a medium.

Similar findings have been shown in Christensen's and colleagues' study (2013) concerning two Danish cohorts. Using survey data, the 1905 and 1915 cohorts were studied when they were 90 years old with regard to their physical and cognitive

functioning. Cognitive ability was measured through the Mini-mental State Examination (MMSE) and a composite of five other tests. It was observed that living longer from more recent cohorts show improvements in general functioning.

Aside from generational differences, histories of individuals also generate improvements in health in general. Nutrition is an important to consider with regard to older persons in Europe. Insufficiency in dietary nutrients is also visible in Europe as evidenced in three countries particularly Northern Ireland, France, and Italy (Hill et al., 2010) and this leads to poorer spatial working memory especially among older women. Apart from nutrition context during adulthood, employment is also assessed. Using the Survey of Health, Ageing, and Retirement in Europe (SHARE) data, it was observed among those who had retired that improvements in health, where cognitive functioning is part and parcel, influenced the decrease in reporting very bad to only fair health statuses (Coe & Zamarro, 2010). The domains of cognitive ability within SHARE include, measurement of disorientation of time and place, word recall, and numeracy. This shows that health is not a factor of retirement but is simply a matter of age inducement.

The comparison of cognitive function measures between countries is cumbersome. Numeracy tests are comparable between SHARE, HRS, and JSTAR as Ichimura and colleagues (2009) had raised; even the measurement on disorientation on spatial and time aspects are comparable since they adopted a portion of the Mini-Mental State Exam. The issue arises with verbal fluency and word recall. Cultural and linguistic factors play a role in asking a list of words to be recited back because of familiarity and societal utility. As exemplified, the word equivalent to “church” is a part of the list in HRS but it is not included for the JSTAR.

The challenge of comparability in measuring cognition was also exemplified in the work of Skirbekk, Loichinger, and Weber (2012) where they compared cognitive function based on immediate word recall using SHARE, HRS, and the World Health Organization's (WHO's) Study on Global AGEing and adult health (SAGE). The WHO-SAGE for their analysis includes China, India, and Mexico while the SHARE measures were decomposed into sub-regions of Northern, Continental, and Southern Europe. For their purposes, the analysis was restricted to immediate word recall because it is present in the survey instruments they had utilised. Other tests on delayed word recall and fluency are often not present in some representative surveys. Due to the differences in conceptualisation and operationalisation of cognitive measures, there are many who encourage that further calibration is earnest and necessary (Chatterji et al., 2008; Hauser & Weir, 2011; Langa et al., 2009; Skirbekk et al., 2012).

It can be observed thus far that framing 'cognitive functioning' is dependent on the availability of data or how the measure is being constructed. As previously discussed, cognition is composed of various tasks and may be depicted in varying degree (d'Esposito & Postle, 2015; Ma et al., 2014; May et al., 1999). The prevalent tests of cognition performed in a more comprehensive manner are the MMSE (Folstein, Folstein, & McHugh, 1975) and the Montreal Cognitive Assessment (MoCA)(Nasreddine et al., 2005). Both were developed to gauge cognitive impairments in patients with differences in the domains of cognition measured and how they are phrased and presented. The MMSE takes between five to 10 minutes to complete and covers temporal and spatial orientation, working memory, attention and calculus, naming, repetition of sentences, command execution, verbal task execution,

and planning. There are individual scoring ranging from zero to 30 where a lower score suggests an elevated impact of impairment. MoCA also takes about 10 minutes to complete and encompasses short-term recall task, visuospatial abilities, executive functions as alternation tasks, phonemic fluency, and verbal abstraction; sustained attention task and serial subtraction to represent working memory; language capability through naming task, repetition of sentences, and fluency task; and lastly, orientation of space and time.

The more prevalently utilised instrument is the MMSE as it had been used in many countries including the United States (Roalf et al., 2013; Roalf et al., 2017) and those in Europe as Denmark (Christensen et al., 2013; McGue & Christensen, 2001, 2002) and Italy (Ravaglia et al., 2008); South America as Brazil (Kochhann et al., 2010), and in Asia as South Korea (Han et al., 2017; Kim et al., 2011; L. Lee et al., 2001) and Japan (Y. Lee & Shinkai, 2005; Shimada et al., 2013). There are also those that use the MoCA in the aforementioned countries especially in the context of comparing the two instruments (J. Y. Lee et al., 2008; Pendlebury, Cuthbertson, Welch, Mehta, & Rothwell, 2010; Pendlebury, Mariz, Bull, Mehta, & Rothwell, 2012; Roalf et al., 2013; Roalf et al., 2017). There is a tendency among such comparisons to favour MoCA especially in studies wherein people are suspected or have cognitive impairment or have NCDs as post-stroke situations (Dong et al., 2010; Godefroy et al., 2011; Ichimura et al., 2009).

There are more tests like the Short Test of Mental Status (STMS) and the different versions of Addenbrooke's Cognitive Examination which bears differences between all other tests (Hodges & Larner, 2017; Kokmen, Naessens, & Offord, 1987; Pendlebury et al., 2012; Roalf et al., 2013; Tang-Wai et al., 2003). This entails the

differences in how cognitive functioning is conceptualised and operationalised. There are limits to representative surveys in various countries as to what can be incorporated in their instruments because the inclusion of comprehensive cognitive functioning tests is not viable. Ichimura and his colleagues (2009) noted that there had been no known national prevalence rate of cognitive decline at the time of their writing. The power of the MMSE, the MoCA, and the like is that they are recognised as predictive of probable cognitive impairments among older people. There are instances where only portions of the MMSE had been adopted toward representative surveys as in the case of SHARE, HRS, and JSTAR. What representative surveys offer is cross-sectional information on the sample of who has normal or less than normal cognitive functioning and this is to be interpreted only by referring to the delimitation of the survey instrument.

2.2. Social characteristics and cognitive ability

This section contains individual characteristics related with cognitive ability and performance among older persons: demographic attributes (2.2.1), socioeconomic characteristics (2.2.2), and social engagement (2.2.3).

2.2.1. Demographic attributes

Selected demographic characteristics have been presented in the literature with regard to cognition. Among these factors is residence. It has been observed that residing in an urban area provides an advantage for older persons (Cassarino & Setti,

2015; Rodríguez-Sánchez et al., 2011). It was suggested that there are activities available in urban areas considered conducive to cognitive stimulation (Cassarino & Setti, 2015). There is a difference in contention for developing countries as it was observed in China where the accessibility of health services in urban areas may be a factor for improved cognitive performance (X. Zhang et al., 2017).

Another demographic factor found to be contributing to lower cognitive functioning is being single (Basu, 2013; Håkansson et al., 2009). This effect had been suggested to be related with the emotional state of older people whereby they avoid the feeling of depression if they are in a union (Lei Feng et al., 2014). Residence and marital status have social mechanisms on how they manifest their effects on cognitive functioning. Gender, on the other hand, has both biological underpinning, apart from the social aspect, that may have effect on cognition.

Health differences are present between males and females. Women tend to live longer than men regardless of being in a developed or a developing country (Barford, Dorling, Davey Smith, & Shaw, 2006). Japan for a long period was observed to have a continuously increasing gap between men and women which was not observed in other G7 countries (Trovato & Heyen, 2006). In developing countries, women still have the advantage but it was much less prominent (Jagger et al., 2008). Such gender differences may be due to biological differences or societal forces (Rieker & Bird, 2005).

When comparing gender through biological dissimilarities with regard to chromosomal and hormonal aspects; there are indications that these have an effect on cognitive function (Mielke, Vemuri, & Rocca, 2014). In their review with regard to the U.S.'s case (Petersen et al., 2010), males have higher risk of MCI which is the

stage of cognitive decline between normalcy and dementia. Though Mielke and colleagues (2014) note, women tend to bear much severe negative impact of cognitive dysfunction because males experience mortality earlier and therefore those who are more resilient survive.

Observations from diagnostic tests show varying results to represent the social factors of cognitive function among older persons. In a study comparing Denmark, Japan, and the United States, it was found that many differences were observable between them (Oksuzyan et al., 2010). Immediate recall scores have shown that Denmark performed poorer than older persons in the other countries. MMSE scores comparing the genders between countries conjunctively showed US women had higher scores across all ages while it was the opposite among Danish women.

Analysing the context of older persons is also important. In a dated study in Shanghai, China, the researchers have shown that there was an exceptionally higher rate of cognitive dysfunction in the said city than the national rate and even compared with other countries as Japan and the US (M. Zhang et al., 1990). They observed that increasing age, having low education, and being female increased the decline in cognitive function. What they emphasised was the interplay of the factors whereby females who were already considered older persons had not receive formal education which may have exacerbated the prevalence of dementia compared with males. In the case of Latin America and the Caribbean, gender was also a factor considered in cognitive function among other health outcomes (Zunzunegui, Alvarado, Bé, & Vissandjee, 2009). The survey called *Salud, Bienestar y Envejecimento* (SABE) was performed in select cities across the said region. Adjusting for exposure to vulnerabilities across the lifespan as hunger, education, poverty, and income; the

authors observed that women had poorer self-rated health, cognitive impairment, and disabilities across the cities in the region compared with males.

These studies present different results as to the status of cognitive function among older persons for societies at various time periods. There is indication that men were vulnerable to cognitive impairment that women although when the latter experience it, a more devastating form of dysfunction occurred (Mielke et al., 2014). Other studies state the opposite where women have the higher risk but it may be due to historical or social context (M. Zhang et al., 1990; Zunzunegui et al., 2009). This affords each country to be studied regarding cognitive function and its determinants. This has yet to be performed in Thai society in a comprehensive, nationally-representative manner.

2.2.2. Socioeconomic status

Socioeconomic status, being a composite of education, occupation, and income, has been observed to have effects on health among older persons (Adler et al., 1994; Schöllgen, Huxhold, & Tesch-Römer, 2010). Exemplifying this was a study on subjective health rating involving the SHARE data offers six domains which includes: mobility, pain, sleep, breathing, emotional health and cognition (d'Uva, O'Donnell, & Van Doorslaer, 2008). It was observed that older persons with higher education level perceive themselves in worse health across all domains in all European countries involved in the dataset excluding Spain and Sweden. In terms of the outcome of cognitive function and health, it was seen that education and other SES aspects have a

protective effect even in terms of overt cognitive diagnostics (McEwen & Gianaros, 2010a; Yaffe et al., 2013).

Income, another indicator of SES, has been observed to affect cognitive health (Sachs-Ericsson & Blazer, 2005; Yaffe et al., 2013). There are different mechanisms involved in how this effect is manifested. Studies had alluded that having lower income causes physiological stress among individuals which subsequently affects biological dysregulation in the brain directly or through other health dimensions as cardiovascular processes which then influences cognitive health and functioning (McEwen & Gianaros, 2010a, 2010b; Sachs-Ericsson & Blazer, 2005). There are also studies which had explored the social mechanism between income and cognition (Litwin, 2009; Yaffe et al., 2013). Litwin (2009) studied selected Mediterranean and non-Mediterranean older populations and found that financial distress affects participation in social activities which then have ramifications toward cognitive health and functioning. Another social mechanism is the identification of occupations whereby cognitively demanding employment would have higher income gains (Banks & Mazzonna, 2012).

It is often the case in studies that education is taken distinctly from other SES components because of its impact in health or other outcomes. A study on cognitive function and how it was affected by education and wealth had been done in the U.S. (Cagney & Lauderdale, 2002). They observed that education was minimally attenuated when income had been controlled but wealth effect was greatly reduced when adjusted for education. Karp and colleagues (2004) differentiated occupation-based SES and education and their effects on the experience of Alzheimer's disease. They found that incidence of dementia and other cognitive impairments were higher

among those with lower SES but, once education had been factored, this effect was diluted and much of the effect on the presence of cognitive impairments were brought by the latter factor. Zahodne and colleagues (2017) also analysed this comparison in the U.S. across different age groups. They had observed income having stronger effects on cognition only in younger years while education greatly affected cognitive functioning in middle and older ages.

There have been debates particularly within the dimension of cognitive health whereby some claim that even though education level indicated an effect with regard to social aspect of life, there may not be necessarily an effect on cognitive development itself (Deary & Johnson, 2010) although there are those who counter this contention (Richards & Sacker, 2011). Studies are also present where they explore how such a social factor may affect the cognitive development in such a way that a biological effect occurs where a protective factor develops in the brain when education increases (Stern, 2006).

Similar to the study of Zahodne and others (2017), education may lead to gradients in terms of health which had been studied for some time and among people of different ages but had been mostly focused on developing countries (Adler et al., 1994; Evans et al., 1997; Noble, Norman, & Farah, 2005). It demonstrated the effect of education on improved cognitive functioning based on survey instruments for multiple countries including developing ones (Weber & Skirbekk, 2013). They identified that there may be differing contributions of education to cognitive function but in general, they shared the result of other studies where education has a protective role in cognitive health.

2.2.3. Social engagement

Social engagement factors are suggested to play important roles in cognitive performance in old age but have received less attention in the literature. These factors include living arrangements and social participation. Within the available studies on living arrangement of older people, most observations were based on Western populations, and their findings are inconclusive and contradicting. Studies in Western contexts suggested the negative effects of living alone on the physical and mental wellbeing of older persons, including disease susceptibility, depression, and mortality (Bordone & Weber, 2012; Chatterji et al., 2015; Köhler et al., 2010). Mazzuco and colleagues (2017) on the other hand indicated that living with children can be detrimental to cognitive performance depending on geographical context due to the stress level brought about by variations in family dynamics.

Social participation refers to the maintenance of social connections and participation in communal activities (Krueger et al., 2009). This has been found to moderate the adverse effects of solo dwelling among older persons (Bilotta et al., 2010; Zhu, Hu, & Efird, 2012). While prior studies have reported consistent findings that older adults with higher social participation are generally more likely to have higher levels of cognitive function (James, Wilson, Barnes, & Bennett, 2011; Krueger et al., 2009; Zunzunegui, Alvarado, Del Ser, & Otero, 2003), the extent of the association varies by type of activity examined. Some social activities, such as volunteering, visiting friends, and other group activities; stimulate better cognitive performance (Weber, 2016) and are therefore more attractive to those who have a

high level of cognitive ability (Aartsen, Smits, van Tilburg, Knipscheer, & Deeg, 2002).

Research on the topic of socialisation factors on cognitive ability in developing Asia has only emerged recently. In Thailand, in particular, even though selected research has addressed cognitive function in later life (Charernboon & Lerthattasilp, 2016; Phrommintikul et al., 2018; Taboonpong, Chailungka, & Aassanangkornchai, 2008; Yuenyongchaiwat, Pongpanit, & Hanmanop, 2018), to the author's knowledge, all studies have been undertaken in either clinical or community settings and focused largely on medical aspects. As a result, there is a lack of national-level statistics on the cognitive health of older persons. Only a few nationally representative datasets collected information related to cognitive performance. Within these datasets, information regarding older persons' socioeconomic characteristics, fertility, family and involvement in social activities had been limited.

2.3. Novel perspectives and approaches to cognitive ageing

The following subsections expound on the literature which focuses on the further need for a reorientation of the concept of old-age dependency (2.3.1) and analytic approaches to cognitive ageing (2.3.2).

2.3.1. Reorientation of the concept of old-age dependency

Within the themes of physical, psychological, and cognitive health limitations in ageing studies, there is a notion that reaching a particular age is the criteria for being

considered an older person and therefore live in dependency. There are criticisms to this view because it solely considers chronological age ignoring social characteristics that may bear different effects on health states (Sanderson & Scherbov, 2007, 2016). This calls for the need to refine some measures within the study of ageing and this has been the goal of some studies particularly those of Sanderson's and Scherbov's (2008, 2010). As a hypothetical example, someone aged 60 years in recent years will have a life expectancy of that of a 43-year-old in 1800s. The fundamental concern is that there would be a caveat on determining who among the people aged 60 years and over are to be considered as dependents from perspectives that include functioning and health state. There had been studies concerning the integration of disabilities to ageing issues (Lafortune & Balestat, 2007; Manton, Gu, & Lamb, 2006). Since many more among those currently in the older ages have better health functions than previous cohorts, considering everyone as dependent would be imprecise. Sanderson and Scherbov (2010) had proposed such inclusion of health indicators into the traditional definition whereby it becomes the adult disability dependency ratio (ADDR) where the ratio represents the number of adults at least aged 20 years with disabilities to those without disabilities.

Differences in health capacity and functioning are related to the onset of diseases among the older population. This is related to the observation that certain characteristics can change the speed of ageing for different persons (Sanderson & Scherbov, 2014). Through this perspective, the traditional measure in demography, the old-age dependency ratio (OADR), must be reassessed as it is reflective only of dependency from the perspective of labour stock where the employability of people ceases once they reach the age of 65 years old (Sanderson & Scherbov, 2015). In the

said study, it was shown by comparing European societies how various factors would change this perspective of dependency such as economic dependency and healthcare dependency among others. There are subsequent studies that have similar contention from this proposition of reconsidering the dependency measure (Muszyńska & Rau, 2012; Skirbekk et al., 2012)

Muszyńska and Rau (2012) expanded the OADR using data for selected countries in Europe by dichotomising the health status of older persons between those who are healthy and unhealthy. Another study integrates a more specific dependency ratio based on a health dimension which is the cognition-adjusted dependency ratio (CADR) (Skirbekk et al., 2012). CADR represents the ratio of older adults with poor cognitive performance to younger adults together with older adults who have good cognitive functioning. Given these endeavours to expound on the notion of dependency vis-à-vis being healthy, socioeconomic aspects may be assimilated in order to reflect a social reality that is associated with the improving health and well-being of populations (Sanderson & Scherbov, 2014; Sanderson, Scherbov, Weber, & Bordone, 2016).

There is a need in ageing studies to integrate a multidimensional perspective in order to introduce refinements into traditional aggregate measures of ageing. The assimilation of health and socioeconomic factors can reflect the current situation of society such that people may have improved social circumstances, i.e. better healthcare systems, than in previous decades (Sanderson & Scherbov, 2010, 2013).

2.3.2. Analytic approaches to cognitive ageing

Increasing median age, which is one of the common indicators of population ageing, has been characterised in higher-income societies (Sanderson, Scherbov, Lutz, & O'Neil, 2004). This demographic trend then led Sanderson and Scherbov (2005, 2016) to question the approach toward understanding the ageing of populations. Chronological age as a traditional measure focuses on the number of years lived from birth. Consequently, there is the notion that reaching the particular ages of 60 or 65 years then people will have entered the benchmark of being considered *aged*. As peoples' lives are observed to be lengthening, there is a need to consider the number of years left until death or its proportion to the expanding lifespan (Sanderson & Scherbov, 2005).

What Sanderson and Scherbov (2005, 2007, 2008) had done in their seminal works was to standardise median age to compare the remaining years of life between periods. Remaining life expectancy (RLE) can represent health functions better than chronological age when observing different countries and across time. Through this new measure which had been adapted by the United Nations to depict population ageing (Sanderson & Scherbov, 2014), the longevity of people is understood in terms of improving health and environmental context that continuously develop over time.

A related connotation of being considered 'old' or 'aged' is the notion that upon reaching the age threshold of 60 or 65 years, people will have the same level of capacity especially in terms of health and functioning. This tends to be homogenising. An analytic method, the characteristics approach, had been formulated in order to estimate differentiations in terms of the speed of ageing according to social factors (Sanderson & Scherbov, 2010, 2013). This approach involves standardising a health outcome measure and the comparability is through estimating alpha-ages (α-

ages). The α-ages depict the linear change in age given a specific health status level. Studies that have utilised this method had analysed characteristics such as education and race on health outcomes including handgrip strength (Bordone et al., 2015; Sanderson & Scherbov, 2014; Scherbov & Sanderson, 2016).

Cognition and its impairments have been noted to contribute to morbidity (Welmerink, Longstreth, Lyles, & Fitzpatrick, 2010) and to mortality (Andrade, Corona, Lebrão, & Duarte, 2014). Previous definitions of successful ageing has been deficient because cognitive performance or functioning had been largely indisposed although it was shown to be a central feature of living autonomously among people with advanced ages (Fiocco & Yaffe, 2010). As cognition is integrated further into analysis of ageing, it has to be placed in the forefront that not all people undergo cognitive decline in a uniform manner. Different people experience cognitive ageing depending on their pathologies or characteristics (Bordone, Scherbov, & Steiber, 2014; Bordone et al., 2015).

Studies relating social characteristics and cognition utilise a variety of measures depending on the survey data as those found in the SOEP, ELSA, and SAGE (Bordone et al., 2015; Skirbekk et al., 2012). Most of the literature on this area of study had been on ageing developed countries which is primarily due to the availability of data (Chatterji et al., 2015). With the advent of data collection regarding health and social factors in developing countries, such as in Thailand, studies can be done to identify how characteristics by subgroups including education, income, and gender among others manifest themselves with regard to differences in cognitive ageing among people aged at least 60 years.

2.4. Summary

The survey on the literature explored the opportunity for which aspects of cognitive ageing remain unexplored for the population of Thailand. We found shortcomings in the literature which focuses on cognitive ageing in the general context of developing Asia. Although there are studies on this subject matter in Thailand, these are at the community level or mainly involve clinical analyses. Analysing the status and social determinants of cognitive functioning at the national level would contribute to understanding the older population of Thailand.

We also observed that there are various methodological aspects that will contribute to ageing studies. The novel perspective and methods of analyses such as the characteristics approach accounts for the current state of the populations where people are living longer and have different health status than those who lived in past decades. Through this approach, social characteristics are important toward understanding the heterogeneous process of cognitive ageing among the older population compared with the traditional view that chronological age is the sole characteristic that defines being *aged.*

Upon reviewing the various demographic, socioeconomic, and social participation determinants in the literature, we observed that education attainment has great effect on cognitive ageing among older persons. Diverse methods of analyses had been applied to data from countries that also have ageing populations such as those in Europe and East Asia. Traditional concepts in demography such as the OADR had been re-examined to integrate education and health status of populations.

The speed of ageing for education sub-groups had also been analysed for selected economically-developed societies. These methods which utilise education attainment are able to present differences in the experience of cognitive ageing among older people in a society.

Chapter 3: Determinants of Cognitive Ability*

3.1. Overview

It was observed that education attainment was associated with cognitive ability among older adults in many societies based on the review of literature in the preceding chapter (2). In this present chapter, the association between cognitive performance and education attainment is tested by also accounting for other demographic, social, and health characteristics of the Thai older population

3.2. Introduction

A number of studies recently emerged that provided further understanding of how individuals can maintain their cognitive abilities and delay or resist the process of decline in older age (Voss et al., 2010; Yin et al., 2015). While previous studies have focused on the effects of physiological changes due to ageing on cognitive

* The contents of this chapter had been adapted from the manuscript currently being revised for the Social Science Journal with the title: Cognitive function, co-residence and social participation among older persons in Thailand. Some terminologies had been changed for consistency in the present thesis.

health and overlook the fact that cognitive ability varies from one person to another, these recent studies attempt to see how variations among individuals' sociodemographic characteristics, health status, behaviour and lifestyle, both individually and collectively, affect the decline in cognitive function among older persons. Gender, education and economic status are among other sociodemographic factors with well-established relationships with cognitive performance (Lin et al., 2015; Meng & d'Arcy, 2012; Petersen et al., 2010; Weber & Skirbekk, 2013).

Other factors that are associated with cognitive functioning have been studied in recent years particularly those related to social relations as social participation and living arrangement but these are in the context of Western societies (Bordone & Weber, 2012; James et al., 2011; Krueger et al., 2009; Mazzuco et al., 2017). Knodel (2014) noted older people in Thai society has traditionally been living with their adult children although it has been declining in recent years. This co-residence has been observed to protect older people from depression and general social isolation (Chan, Malhotra, Malhotra, & Østbye, 2011; Teerawichitchainan, Pothisiri, & Long, 2015). It may then have further positive effects on other health aspects as cognitive functioning.

In this chapter, we examined covariates associated with cognitive performance. Included here are the following sections: introduction (3.2), research questions (3.3), the methodology (3.4), the results (3.5) and discussion (3.6), and the conclusion (3.7).

3.3. Research questions

This chapter aimed to fill that research gap by using the most recent nationally representative survey data to examine the association of education with cognitive function in conjunction with a broad range of social and health-related factors. Based on the availability of the data, cognitive performance was assessed using an integrated measure of two important domains: memory and numeracy. The questions addressed in this portion of the thesis are:

1. Is education, together with other demographic and socioeconomic factors, associated with cognitive performance among older adults in Thai society?
2. Does the statistical significance of education remain in regression models between men and women when other factors are included as health status and behaviour and social engagement?

3.4. Methodology

Included in this section are the information on the: data (3.4.1), analytic sample (3.4.2), operationalisation of variables (3.4.3), and the methods of analyses (3.4.4).

3.4.1. Data

This study utilises the 2016 Population Change and Well-being in the Context of Aging Society (2016 PCWAS). This will contribute to the shortcoming in the literature by having a national-level study because thus far, studies have been in the rural areas and focused on selected communities.

The 2016 PCWAS was conducted by the College of Population Studies, Chulalongkorn University which addresses two related matters with regard to the structure of the population of Thailand: reproductive health and ageing. For each of these, exclusive questionnaires are implemented whereby in the former, females aged 15 to 49 years were considered for sampling and in the latter, both genders aged at least 60 years are taken as samples. Data collection was done through face-to-face interviews.

Sample units were selected through a four-stage clustered probability sampling method (College of Population Studies, 2018). The first stage is the designation of five areas as strata: Bangkok, Central (excluding Bangkok), North, Northeast, and the South. Five provinces were selected in each of the regions except Bangkok resulting to a total of 20 provinces and Bangkok metropolis. The second stage is gaining a sampling list of districts. Each province is listed with 50 districts while Bangkok is divided into two (2). The third stage is classifying each stratum to 100 enumeration areas (EA's) and through Probability Proportional to Size system of sampling, EA's will be identified where the maximum number of EA's is seven in a given district. Finally, households are selected whereby 30 households are identified for each EA totalling 15,000 households. Households are defined by the project as a home where

at least one person resides and necessitates living. In the case of multiple persons in a dwelling, relatives and non-relatives may be co-residing and still be considered a single household.

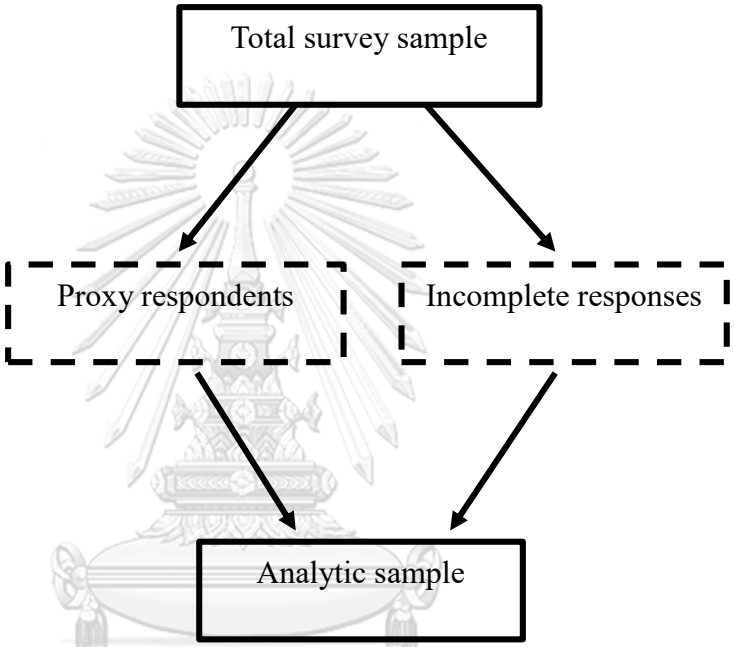
The PCWAS contains a number of indicators on the aspects of cognitive, physical, and mental health. There is another dataset available that focus on these facets namely the National Health Examination Survey (NHES) whereby the latest data is for 2014. This particular dataset expounds more on physical functional limitation, depression indicators, as well as cognitive functioning but, its strength is also its limitation with regard to the current study. The PCWAS contains comprehensive social and demographic variables which are central to this study particularly social engagement. Factors such as living arrangement, social participation, and intergenerational support are considered in the models of analyses based on theories on health. Therefore, the PCWAS is deemed sufficient for the current study.

3.4.2. Analytic sample

For the analyses in this study, the sample was limited to 7,450 persons aged 60 and older. Because all measurements of physical and psychological health adopted in the study are subjective and self-reported, further restriction on the sample was applied to individuals who responded to the survey without assistance from others, and provided valid responses to all questions used in the analysis. Relative to the total older adult sample, cases with proxy respondents account to 2.1 per cent and those

with missing data account for 13.3 per cent (Figure 3.1). With all these restrictions, the analytic sample size comprises 6,301 older persons.

Figure 3. 1. Diagram for analytic sample



Sample restrictions may limit generalisation of findings to all persons aged at least 60 years. Diagnostic analyses then were done between the complete and the analytic sample among males and females. No statistical difference was observed in cognition scores of the said samples for both genders. Analyses were also done for select demographic and socioeconomic characteristics particularly age, marital status, education, and average annual income. No statistical difference for complete and analytic samples was observed among males and females.

To ensure that the sample is representative of the current cohort of Thai older persons, the PCWAS sample demographics (for example, age, gender, marital status, location of residence, and education) were compared to those of the 2017 National Survey of Older Persons in Thailand (SOPT) (National Statistics Office, 2018). Results suggest that the demographics of PCWAS do not diverge significantly from the national demographics.

3.4.3. Operationalisation of variables

3.4.3.1. Cognitive function index

The cognitive function index is constructed based on aggregated scores from two significant domains of cognitive health: memory and numeracy (Fleming et al., 2003; Grady & Craik, 2000; Trott et al., 1999). Memory is assessed through two tasks involving word repetition and recall. In the survey, respondents were instructed to listen carefully to three unrelated Thai words (translated as tree, car and hand) and to repeat these words, in any order, immediately afterwards. One point was given for each correct answer. Respondents were then instructed to memorise these three words and to recall them after completing the subsequent numeracy task. Likewise, one point was given for each correct answer, irrespective of recalled word order. In total, a maximum score of six points was given.

Numeracy was assessed through serial-7s or ‘sevens’ subtraction task. Respondents were asked to assume that they initially had 100 Thai baht and provide the leftover amount after spending seven baht. If the answer was correct, respondents

were asked further to provide the leftover if another seven baht was spent. One point was given for a correct answer at each step, with a maximum score of two. This task was adapted from the Mini-Mental State Examination (College of Population Studies, 2018) by describing the questions in terms of a money transaction and was observed by the survey team to improve respondents' understanding of the questions.

The scores from the two measures were totalled to create the cognitive function index, which ranged from 0 to 8. Higher index scores indicated better principal cognitive function. As indicated by the reliability coefficient, i.e. Cronbach's alpha (0.62), memory and numeracy are acceptable components of the cognitive function index (Hinton, McMurray, & Brownlow, 2014).

Nonetheless, it is crucial to note that this index score is not an approximation of a diagnosis of memory loss or any mental disorder such as dementia or Alzheimer disease. Rather, it provides only the extent to which Thai older adults experienced reduced capability related to memory and numeracy.

3.4.3.2. Independent variables

Several characteristics have been used as independent variables for the analysis. The succeeding description of these variables along with their respective operationalisation is summarised in Appendix 3.1.

Sociodemographic characteristics included age, marital status, educational attainment, location of residence, employment in the past year, average annual income and perceived income adequacy. Age was measured in years and incorporated as a continuous variable. Marital status was incorporated as a categorical variable

indicating whether the respondent was currently married; widowed; or separated, divorced, or never married. Education was measured as a categorical variable indicating whether the respondent received lower than primary education (including no formal education), primary education referring to have completed compulsory education of four to six years; or received higher than primary education. Location of residence was included as a dichotomous variable indicating whether respondents resided in a rural or an urban area. Economic status was assessed via both objective and subjective measures. The objective measures were a dichotomous variable of employment in the past year and a categorical variable of annual personal income in baht. Respondents' perceived economic security was measured as a dichotomous variable indicating whether they had adequate income.

Physical health was assessed through two self-assessment measures: self-reported health and reported physical limitations. Respondents were asked to rate their health status in the past week, with five response categories ranging from 'very good' to 'very poor' classified into a dichotomous variable signifying whether their health was good or poor such that those having at least moderate rating of their health is included under 'Good'. Physical limitation was constructed based on respondents' replies to questions regarding functional activities in daily living (e.g. squatting, lifting heavy objects) and instrumental activities in daily living (e.g. taking a bus, taking medication correctly). Responses of 0 (unable to perform without assistance), 1 (able to perform but with assistance) and 2 (no difficulty) to each question were reverse-coded and converted into a dichotomous variable indicating whether the respondent had at least one physical limitation (α=0.792).

Psychological health was assessed by self-reported frequency of psychological symptoms during the month prior to the survey. The symptoms included loss of appetite; having worries; being upset, moody or irritated; hopelessness; finding life was worthless; being sad and being lonely. Similarly, possible responses ranging from 0 (not at all), 1 (sometimes) and 2 (often) were reverse-coded, summed and converted to create a dichotomous variable indicating whether the respondent experienced at least one psychological symptom (α=0.831).

In the PCWAS, respondents were asked to indicate their frequency of participation in several health-related behaviours such as regular physical exercise, consuming fresh fruits and vegetables, drinking eight glasses of potable water, alcohol consumption and tobacco smoking in the six months prior to the survey. Those who reported undertaking all of the health behaviours, either sometimes or always, were categorised as having healthy behaviour. Alcohol consumption and smoking tobacco were incorporated individually into the model as dichotomous variables indicating whether they drank or smoke, sometimes or always.

Living arrangement was incorporated as a mutually exclusive categorical variable indicating whether the respondent lived alone, with a spouse only, with at least one child only, with a spouse and at least one child, or in other types of living arrangements. The residual ‘other’ category was a mixture of other different situations, such as living only with grandchildren, siblings, friends or caregivers.

Social participation was assessed based on respondents’ answers concerning their involvement in community-based organisations (e.g. clubs for the elderly, cooperative groups or savings groups), community activities (e.g. Thai New Year ceremony), volunteer activities (e.g. organising local festivals) and religious

ceremonies, including offering food to monks. All measures were incorporated separately as dichotomous variables indicating whether the respondent was a member of at least one social organisation, participated in any community activities, undertook volunteer work or attended religious activities in the year prior to the survey.

3.4.4. Methods of analyses

Both descriptive and inferential statistics were employed in the present study to analyse the data. Firstly, descriptive statistics were done to examine the distributions of the cognitive function index and all independent variables both for the total sample and disaggregated by gender. Pearson's Chi-Square and ANOVA tests were employed to indicate the significance of gender differences for all variables. Pearson's correlation test was also performed to ensure that there was no multicollinearity problem among the selected independent variables. For the multivariate analyses, since our dependent variable – the cognitive function index – was constructed from count data, it was deemed appropriate to employ a Poisson regression model (Hayat & Higgins, 2014; Zamani, Faroughi, & Ismail, 2016). An analysis was also performed using the OLS regression model for comparison. The results of the OLS regression analyses by gender (See Appendix 3.2) have shown that the direction of the coefficients and the variables that were statistically significant are similar with what had been observed when using Poisson regression analysis. The difference though is that the standard errors are smaller in reference to the Poisson regression model.

Three additive models are presented for older men and women separately. The first model considered the cognitive function index as a function of sociodemographic

characteristics; the second model added health status and health-related behaviours; and the final model incorporated living arrangement and social participation. Results were presented in terms of coefficients adjusted for all other variables controlled for in the model. Statistical weights provided with the dataset were applied to yield nationally representative results.

3.5. Results

The results are divided to three sub-sections: the sample description (3.5.1), the cognitive function index (3.5.2), and the multivariate analyses (3.5.3).

3.5.1. Sample description

Table 3.1 presents the distributions of all independent variables employed in this study for all older adults in the sample and according to gender. The average age of older adults in the samples was 68–69 years. The vast majority had completed primary education with men (23 per cent) significantly more likely than women (12 per cent) to have completed schooling higher than primary level. Nearly two-thirds of older Thais were currently married at the time of the survey. More women were unmarried than men. Fewer than half of the older persons lived in urban areas. In terms of economic status, approximately half had worked during the past year, but the proportion was significantly higher for men than women. Although a larger proportion of men had a high average annual income, particularly in the range of

100,000 baht and above, there was no difference between men and women with respect to the perception of income inadequacy.

Men were significantly more likely than women to report better health status, while women were more likely to experience physical limitations and at least one psychological distress symptom. Smoking tobacco and using alcohol were significantly more prevalent among men than women. At the same time, men were more likely than their female counterparts to undertake health-enhancing practices.

Regarding living arrangements, the majority of older Thais co-resided with their children, with about one-third living with their children only. The proportion living with a spouse only was greater among men than women, while women were more likely to live alone. Overall, older Thai people were actively engaged in social activities. However, the proportions of men in all types of activities were significantly higher than those of women, except in religious ceremonies.

Table 3. 1: Descriptive statistics of analytic variables by gender, Thai older adults aged 60 and over

Variable	Total	Male	Female	p-value[a]
Mean age	68.7	68.6	68.8	0.152
	Percentages			
Age group				
60–69	60.9	62.3	59.8	0.129
70–79	30.7	29.9	31.3	0.280
80 and over	8.4	7.8	8.9	0.441
Residing in urban area	40.4	39.8	40.9	0.417
Marital status				
Married	66.5	84.1	52.8	0.000
Widowed	25.8	11.8	36.6	0.000
Separated/divorced/never married	7.8	4.1	10.6	0.000
Education level				
Lower than primary level	14.4	10.3	17.6	0.000
Primary level	68.8	66.8	70.3	0.000
Higher than primary level	16.8	22.9	12.2	0.000
Employed in the past year	51.4	62.8	42.5	0.000
Average annual income				
Less than 30,000	44.4	39.8	47.9	0.000
30,000–59,999	22.8	22.5	23.1	0.918
60,000–99,999	11.8	12.9	11.0	0.037
100,000 and above	21.0	24.9	17.9	0.000
Perceived income adequacy	53.5	53.2	53.7	0.772
Self-rated health				
Poor	24.1	18.8	28.2	0.000
Good	75.9	81.2	71.8	0.000
Experienced 1+ physical limitation	49.5	34.3	61.3	0.000
Experienced 1+ psychological distress symptom	69.3	62.9	74.2	0.000
Positive health behaviour	82.1	86.2	79.0	0.000
Smoking cigarettes	17.1	34.7	3.4	0.000
Drinking alcohol	18.6	32.5	7.9	0.000
Living arrangement				
Alone	10.5	8.0	12.4	0.000
Spouse only	17.4	21.9	13.9	0.000
At least one child only	32.4	33.3	31.7	0.433
Spouse and children only	22.9	22.5	23.2	0.817
Others	16.9	14.4	18.9	0.000

Membership of at least one organisation	78.6	80.2	77.3	0.015
Participated in community activities	52.2	54.2	50.7	0.046
Participated in volunteering activities	61.1	67.4	56.3	0.000
Religious engagement	87.5	86.5	88.3	0.063
Number of observations	6,301	2,611	3,690	

Source: The 2016 PCWAS.

[a] Chi-square test and ANOVA were conducted for categorical and continuous variables, respectively.

3.5.2. Cognitive function index

Scores from memory and numeracy tests are presented in Table 3.2. On average, older Thais recalled 5.12 words (SD 1.2, min=0, max=6) and counted backward correctly 1.21 times (SD 0.71, min=0, max=2). The mean value of the cognitive function index (0–8) of all older persons was 6.3, with men having significantly higher cognitive performance scores than women, at 6.4 and 6.2, respectively.

Table 3. 2: Memory scores, numeracy scores and cognitive function index by gender, Thai older adults aged 60 and over

	Total		Male		Female	
	Score	Adjusted means	Score	Adjusted means	Score	Adjusted means
Recall (0–6)						
Below primary education	4.5	4.5	4.6	4.5	4.5	4.5
Primary education	5.1	5.1	5.2	5.2	5.1	5.1
Above primary education	5.4	5.4	5.4	5.4	5.5	5.4
Numeracy (0–2)						
Below primary education	0.7	0.7	0.8	0.8	0.7	0.7
Primary education	1.1	1.1	1.2	1.2	1.1	1.1
Above primary education	1.6	1.6	1.5	1.6	1.6	1.5
Cognitive function index (0–8)						
Below primary education	5.3	5.2	5.4	5.3	5.2	5.2
Primary education	6.3	6.3	6.4	6.3	6.2	6.2
Above primary education	7.0	7.0	6.9	7	7.1	6.9

	Total	Male	Female	p-value[a]
Recall (0–6)				
Mean	5.122	5.169	5.089	0.042
SD	1.209	1.188	1.223	
Numeracy (0–2)				
Mean	1.209	1.260	1.173	0.000
SD	0.714	0.711	0.713	
Cognitive function index (0–8)				
Mean	6.3	6.4	6.2	0.000
SD	1.559	1.530	1.583	
Total (n)	6,301	2,611	3,690	

Source: The 2016 PCWAS.

[a] ANOVA was conducted to test the difference between genders

3.5.3. Multivariate analyses

Table 3.3 reports the Poisson regression coefficients, indicating the size of the effect and statistical significance that each category of independent variable has on the cognitive function index relative to the reference category. Age was strongly and negatively associated with lower cognitive performance in both men and women. The negative coefficients for age remained strongly significant after all other variables, including living arrangement and social participation, were controlled for (Models 2, 3, 4 and 5). Results further showed that education background was associated with significantly improved old-age cognitive function for both men and women. Regardless of whether or not all other variables were taken into account, its associated benefits with cognitive function is higher for women than men.

The Poisson coefficients were statistically non-significant after other variables were controlled for. The coefficients of employment during the past year showed inconsistent results for older men and women, with older women who continued to work being more likely to have better cognitive health. However, neither association was statistically significant. Results further indicated a positive association between annual income and old-age cognitive function. The size of the income effect was greater for men than women, regardless of whether other variables were controlled for. The perception of income adequacy was found to have a positive correlation with cognitive function for both men and women. While the coefficients for older men remained significant (Models 2 and 3), those for older women became slightly smaller

and insignificant after health status, health-related behaviour, living arrangement and social participation were accounted for (Models 5 and 6).

In addition to sociodemographic characteristics, multivariate results indicated the positive significance of health-enhancing practices on men's cognitive performance. Although the coefficients of tobacco smoking and alcohol consumption showed negative associations with cognitive function for both men and women, neither was statistically significant. The associations of physical limitation and psychological distress with cognitive function were inconsistent for older men and women. While experiencing physical limitation was associated with significantly worse cognitive health for older men, this was not the case for older women. On the contrary, although the coefficients of psychological distress showed a negative association with old-age cognitive health for both men and women, the association was statistically significant for women only, regardless of whether all other variables were considered.

Multivariate results also showed that co-residing with others, especially children, improved the cognitive health of older adults. However, the association was true for men only. None of the social activities, except religious activities, showed a significant effect on the cognitive performance of older Thais, and the positive effect of religious engagement was true for men only.

Table 3. 3: Poisson regression coefficients of analytic variables by gender, Thai persons aged 60 years and over

	Males			Females		
	M1	**M2**	**M3**	**M4**	**M5**	**M6**
Age	-0.007***	-0.007***	-0.007***	-0.008***	-0.008***	-0.007***
Residence (Rural=ref)	0.014	0.016	0.013	0.015	0.016	0.015
Marital Status (Married=ref)						
Widowed	-0.034	-0.028	-0.014	-0.002	-0.003	-0.003
Separated/divorced/never married	-0.036	-0.025	-0.001	-0.007	-0.006	-0.009
Education level (Below primary=ref)						
Primary level	0.124***	0.115***	0.112***	0.146***	0.142***	0.142***
Higher than primary level	0.176***	0.162***	0.159***	0.247***	0.240***	0.237***
Employed in the past year (No=ref)	-0.001	-0.009	-0.009	0.007	0.006	0.003
Average annual income (<30,000=ref)						
30,000–59,999	0.051**	0.048**	0.044**	0.045**	0.044**	0.043**
60,000–99,999	0.054**	0.050**	0.047**	0.033*	0.032**	0.028**
100,000 and above	0.056***	0.053***	0.050**	0.042**	0.041**	0.037**
Perceived income adequacy (No=ref)	0.039**	0.033**	0.035**	0.026**	0.020	0.019
Self-rated health (Poor=ref)		0.005	0.01		0.01	0.01
Experienced 1+ physical limitation		-0.038**	-0.035**		-0.015	-0.013
Experienced 1+ depressive symptoms		-0.01	-0.007		-0.042***	-0.042***
Smoking cigarettes (No=ref)		-0.015	-0.014		-0.001	-0.006
Drinking alcohol (No=ref)		-0.005	-0.004		-0.018	-0.019
Positive healthful behaviour (No=ref)		0.042*	0.036*		0.026	0.024
Living arrangement (Alone=ref)						
Spouse only			0.052			0.001
Child only			0.064**			0.005
Spouse and children			0.055*			0.005
Others			0.062*			0.005

Membership of at least one organisation			0.016			0.02
Participated in community activities			0.013			0.01
Participated in volunteering activities			0.009			0.015
Religious engagement			0.049**			0.021
Constant	2.215***	2.188***	2.096***	2.205***	2.215***	2.197***
F statistic	5.39**	2.14**	1.22	4.54**	3.19**	0.73

*, ** and *** denote significant differences between older men and women for P≤0.10, P≤0.05 and P≤0.001, respectively.

Education and income are correlated as in most studies. As observed in the regression analyses above for men and women, the two factors are the only consistently statistically significant social covariates. It was necessary then to assess the relationship between the education and income. To do this, an interaction term is introduced given the two factors bear different operationalisation from the models previously presented. Education was redefined to be dichotomous such that those with levels higher than primary education is grouped in one category and all others are grouped otherwise. Income on the other is operationalised into two quantiles with the lower income level being the reference category.

The results of testing the interaction terms through regression analyses is in Table 3.4. The interaction between education and income are not statistically significant while the main effects of the socioeconomic variables remain to be statistically significant. This shows that education and income have mutually exclusive effect on cognitive performance while being correlated.

Table 3. 4: Association of the interaction of education and income on cognitive performance by gender, Thailand

	β	**SE**	**p-value**
Male			
Higher than primary level	0.048	0.026	0.061
Higher income level	0.044	0.015	0.005
(Education)(Income)*	0.011	0.028	0.704
Female			
Higher than primary level	0.090	0.024	0.000
Higher income level	0.027	0.014	0.046
(Education)(Income)*	0.022	0.026	0.406

**Models controlling for the same demographic, socioeconomic, health behaviour health dimensions, living arrangement, and social engagement covariates*

3.6. Discussion

Cognitive decline in later life is a theme that has been overlooked in the literature from a social perspective specially in a developing Asian country setting. The main contribution of this study is to demonstrate the association of education attainment with cognitive performance during advanced ages for both males and females. Furthermore, the inclusion of factors reflecting the local cultural context such as living arrangement and social engagement is key in order to have a more developed perspective of cognition as a health dimension.

The findings in this study is in line with the literature (Oksuzyan et al., 2010; Park & Festini, 2017) which indicate that age has a strong net negative association with cognitive function for both genders. Although some studies suggested that cognitive performance tends to decline more rapidly in women than men (Wang, Zheng, Kurosawa, & Inaba, 2009; Zunzunegui et al., 2009), evidence is not found to support this claim when living arrangement and social participation were taken into consideration. In lieu with the cognitive reserve theory (Stern, 2002) and its application in population-level studies (Wilson et al., 2009; Yaffe et al., 2013), education attainment demonstrated a significant correlation with cognitive function in advanced ages. Older Thais with primary education or higher had significantly better cognitive function than those with lower educational level. Findings demonstrate further that the benefit of education on cognitive function is greater for older women than men. This agrees with the theory of resource substitution, which states that the lack of one resource is compensated for by another (Ross & Mirowsky, 2010).

Women tend to have fewer socioeconomic resources particularly in the form of power and earnings therefore, the effect of education can become more pronounced. Several prior studies have shown that employment can significantly affect older persons' cognitive health, either positively or negatively, depending on various factors, including the characteristics of the job and the level of employment (Adam, Bonsang, Grotz, & Perelman, 2013; Capurso et al., 2000). Such an association did not appear in our findings; in fact, our results were to the contrary such that it lacks association, akin to other studies (Schiller, Lucas, & Peregoy, 2012; Yaffe et al., 2013).

Our results showed a strong positive net income association with cognitive function in old age. Financially-disadvantaged older persons may have limited access to preventive healthcare services such as annual health examinations; therefore, their cognitive health is less likely to be screened (Quashie & Pothisiri, 2019). Another possible explanation is that income can facilitate leisure activities (e.g. piano playing, travels) that have been demonstrated in many studies to stimulate brain function (Seinfeld, Figueroa, Ortiz-Gil, & Sanchez-Vives, 2013; Tesky, Thiel, Banzer, & Pantel, 2011). It is further shown in this study that not only objective income but perceived income adequacy may also play an important role in cognitive function in older age, although this observation applies only to men. A possible mechanism is that perception of income inadequacy creates stress, which perhaps translates into biological dysfunction impacting various bodily functions, including brain function (Beckie, 2012). For older women, the positive effect of perceived income adequacy on cognitive performance was observed but this is based on models with limited specification. The said effect dissipated once health-related factors were included.

Further investigated in this study is which health-related factors truly moderated the effect of perceived income adequacy by entering one variable at a time and found that the relationship between perceived income adequacy and cognitive performance became non-significant when psychological symptoms were incorporated.

These findings broadly support the extant literature indicating the significance of physical and psychological health in the performance of cognitive function (Durant, Leger, Banks, & Miller, 2016; Köhler et al., 2010; Wolitzky-Taylor, Castriotta, Lenze, Stanley, & Craske, 2010). However, the two health indicators demonstrated different impacts on men and women. The explanation for this difference was not evident in this study. Additional research is needed to determine the robustness of the findings and their underlying mechanisms.

While previous studies have indicated relationships between cognitive function in old age and tobacco and alcohol consumption (Hagger-Johnson et al., 2013; Y. Lee et al., 2010), these associations were not observed in this study; neither among older men nor women. This result may be attributable to other health behaviours or existing conditions in such a manner that, although there is a strong association of cognitive decline with these modifiable behaviours, the mechanism of this effect remains unclear (Durazzo, Meyerhoff, & Nixon, 2010).

In Thailand, as in much of the developing world, care and support of older parents remain a strong commitment for adult children (Knodel, Prachuabmoh, & Chayovan, 2013). Co-residence is known as the main vehicle with which to facilitate the provision of care and support to parents and to protect them from depression and social isolation (Chan et al., 2011; Teerawichitchainan et al., 2015). This study demonstrates another benefit of living with children, similar to what Mazzuco et al.

(2017) found in Belgium. Results suggest, for older men, co-residence with children provides a significantly greater cognitive benefit than co-residence with both children and spouse or other forms of living arrangements. For older Thai women, it was observed that those who lived with children only or in other forms of living arrangements did not necessarily perform better cognitively than those dwelling solo. This observation between the difference in result between men and women is similar to the observation among older persons in Korea with regard to mental health (Jeon, Jang, Rhee, Kawachi, & Cho, 2007; Oh et al., 2015). Oh and colleagues (2015) explained the gender difference is related to societal roles between genders whereby middle-aged males are beneficiaries of care from their wives and even family therefore if they were to be left alone in life, their well-being declines.

Interacting with other people involves multiple brain functions, facilitating a reserve of healthy brain cells and the connections between them (Lebreton et al., 2009). Although social engagement has been extensively reported to have positive implications on cognitive health, such observations were not evident in our study, with the exception of the engagement of older men in religious ceremonies. One possible explanation, as previously described by Weber (2016), is that the type of activities that are beneficial to cognitive function must be brain-stimulating, while the social activities explored in this study may not fall into this category.

It was important to use an extensive array of social characteristics to test if there are confounding factors apart from education attainment with regard to the older population in Thailand. This agrees with majority of the previous literature that had been mostly representative of studies concerning economically-advanced societies. Although this study has the aforementioned contribution to the literature, further

studies can be performed when data is available such as including data on specific illnesses or comorbidities of individuals as these aspects are absent in the 2016 PCWAS.

3.7. Highlights

- The Poisson regression model analysis was appropriate to analyse cognitive performance which was measured as a count variable.
- Education and income were observed to be consistently associated with cognitive performance among older men and women in Thailand.
- Having physical limitations was found to be associated with cognitive ability among men while the experience of depressive symptoms was associated with the outcome among women.
- Selected living arrangement contexts and religious engagement were associated with cognitive ability among older males only.

Chapter 4: Present and Prospective Prevalence of Lower Cognitive Performance [2]

4.1. Overview

In the previous chapter (3), education attainment, income level, and age were observed to be associated with cognitive ability for both older men and women. From these findings, education was applied in this current chapter by being integrated into the old age dependency measure through the estimation of the prevalence of lower cognitive performance of the current Thai population. This is expanded into future populations with the use of education-specific population projections. Income-specific population projections are not available therefore income level is not included in the analyses.

4.2. Introduction

The old-age dependency ratio (OADR) has been criticised as it is reflective only of dependency from an economic perspective of the employability of people based on age (Sanderson & Scherbov, 2015). The fundamental concern is the caveat on

[2] The texts, tables and figures presented in this chapter have been adapted from the following paper:
Vicerra, P. M. M., & Pothisiri, W. (2020a). Cognition-adjusted Dependency Ratio among later-life adults and the Role of Education. Journal of Public Health and Development. Some terminologies had been changed to attain consistency in the present thesis.

determining who among the people aged 60 years and over are to be considered as dependents from the perspective of health status and functioning. Since many more among those currently in these older ages have better health functions than previous cohorts, considering everyone as dependent would be imprecise. This approach on dependency is done by Skirbekk and colleagues (2012) particularly on cognitive health. Such type of analysis is lacking in the context of developing countries.

Another aspect that has shortcomings in the literature is the intersection of health and socioeconomic status of the older population and how it is reflected in the measures of old-age dependency. In Thailand, it has been observed that there is a positive effect of education levels on select health indicators; an example is self-rated health (Zimmer & Amornsirisomboon, 2001). This observation was supported by the study by Loichinger and Pothisiri (2018) where they had estimated the effect of education with the prevalence of ill-health based on the current population and how much impact it may have in future populations. What is lacking still in the literature is integrating the concepts and methods utilised in order to introduce refinements into traditional aggregate measures in the study of ageing, i.e. OADR, and apply it further on future populations.

Socioeconomic status also includes income which was also observed in the literature to have association with cognitive health (Sachs-Ericsson & Blazer, 2005; Yaffe et al., 2013). Also, it had been observed in the results of Chapter 3 of the present thesis that income was associated with cognitive performance among older men and women in Thailand. For the study in this current chapter, income is not utilised in the analyses because there is no population projection factoring income levels. An objective in this study was to apply SES to population projections. The said

population projections considered education characteristics and not income (Wittgenstein Centre for Demography and Global Human Capital, 2018). Despite this, the measure for SES is valid because education had been shown to be a mediator and a proxy for income based on literature in recent decades (Banks & Mazzonna, 2012; Ross & Mirowsky, 1999; Sachs-Ericsson & Blazer, 2005; Williams, 1999).

This chapter presents the general association of health and education through the estimation of ill-health prevalence rates. It starts with the introduction (4.2) followed by the research questions (4.3). The following sections are the methodology (4.4) and results (4.5); and trailed by the discussion (4.6) and the conclusion (4.7).

4.3. Research questions

This study aimed to present prospective levels of health dependency among the older population in Thailand which had been relatively overlooked in the literature thus far. This was elaborated through the application of ill-health prevalence rates on population projections. These novel approaches to the study of health of current and future older populations is important for a country such as Thailand. To address the issues, the following questions are explored:

1. What is the prevalence of lower cognitive performance by education attainment?
2. How different are the prevalence of lower cognitive performance when comparative models with and without education differentials are applied to population projections?

3. How does the traditional old-age dependency ratio change when cognitive performance and education factors are considered for current and future populations?

4.4. Data and analytic approach

This section contains information on the data (4.4.1) subdivided into the information on older persons in Thailand (A) and the population projections by education attainment (B). The following subsection on methods of analyses (4.4.2) is divided into the following: thresholds of poor health (A), prevalence of ill health (B), application of predicted rates to population projections (C), and the health-adjusted dependency ratio (D).

4.4.1 Data

The data sources for this study include cross-sectional data from surveys of older persons in Thailand and population projections by age, gender and educational attainment.

4.4.1.1. Information on older persons in Thailand

Thailand has collected much information on older persons over the past years. This present study utilises multiple datasets: The Survey of Older Persons in Thailand (SOPT) and the Population Change and Well-being in the Context of Aging Society

(PCWAS). The SOPT has been implemented multiple times and for the current study, the 2011 and 2014 data points were used. These SOPTs used a three-staged stratified sampling design covering individuals aged at least 50 years in both urban and rural areas across major regions in the country (National Statistics Office, 2012, 2014). This present study also used the PCWAS which had been described in detail in section 3.4.1.

For the three surveys stated previously, information on demographic and socioeconomic background along with self-reported health indicators of the respondents were collected. Although some health-related items are not consistently present across these surveys; specifically, depression and anxiety symptoms and cognitive performance, the SOPT and PCWAS used standardised definitions in terminologies. This use of multiple time points is to analyse if there are trends in the health indicators which can be subsequently used in estimating prevalence rates for application to population projections.

Selected characteristics are presented in Table 4.1. The proportion of females and the those in the age group of 60-64-year-olds are consistently higher than other categories in all surveys. Primary education consists of 4 to 7 years of primary level of education which is compulsory. This category has the highest proportion in all three surveys but it is declining such that 75 per cent of the older population were included in it compared with about 69 per cent in 2016. Having any level above primary education is also increasing in proportion for the samples in 2011, 2014 and 2016. Sampling weights have been applied for the analyses of the three surveys to account for the spatial distribution of the older persons in Thailand.

Table 4. 1: Descriptive statistics of samples; 2011, 2014, and 2016.

	2011	2014	2016
Gender			
Male	42.6	44.3	41.4
Female	57.5	55.8	58.6
Age distribution			
60-64	32.0	32.2	34.8
65-69	22.2	23.5	25.7
70-74	18.8	17.0	19.6
75-79	13.5	13.7	11.4
80 and over	13.6	13.6	8.5
Education distribution			
Below primary education	12.0	15.3	14.4
Primary education	75.0	68.5	68.8
Above primary education	13.0	16.2	16.8
Total Sample	34172	38695	3611

Sources: 2011 SOPT, 2014 SOPT and 2016 PCWAS

For a detailed sample distribution by age group according to education level, refer to Appendix 4.1.

4.4.1.2. Population projections by education attainment

The population projections should be according to age, gender and education characteristics for the current analysis. The Wittgenstein global population projections include these features such that past and projected population data are presented by highest education attainment for 201 countries (Lutz, Goujon, KC, Stonawski, & Stilianakis, 2018; Wittgenstein Centre for Demography and Global Human Capital, 2018). The base year for the projections is 2010 and the results are presented in 5-year

intervals and differentiated by gender. The classification of education levels is based on ISCED97 which are: no education, incomplete primary, primary, completed lower secondary, completed upper secondary and post-secondary.

The population projection results are for seven scenarios with varying assumptions including population processes of fertility, mortality, and migration; and the population characteristic of education attainment (Wittgenstein Centre for Demography and Global Human Capital, 2018). The assumptions utilised in these projections are borne of rigorous analysis of historical and current developments of such population processes. Opinions of experts about the future development of the parameters, which was collected through online survey, was also part of the assumptions. The strength of these education-specific projections is that they have been continuously updated and validated. It has to be noted that these population projections are deterministic and therefore uncertainty cannot be quantified. Rational reasoning and the comparison of outcomes on future scenarios regarding fertility, mortality and migration have to be considered for defining such uncertainty. Further information on method and assumptions of these projections are provided in Lutz et al. (2018), Lutz, Butz, and KC (2014) and KC, Potančoková, Bauer, Goujon, and Striessnig (2013).

The education attainment of persons aged 60 years old and over in Thailand between 2015 and 2050 are presented in Table 4.2. More males have attained above primary education in 2015. This difference dissipates in 2050 when both genders have very similar levels such that majority of the population in later ages have higher than primary level of education.

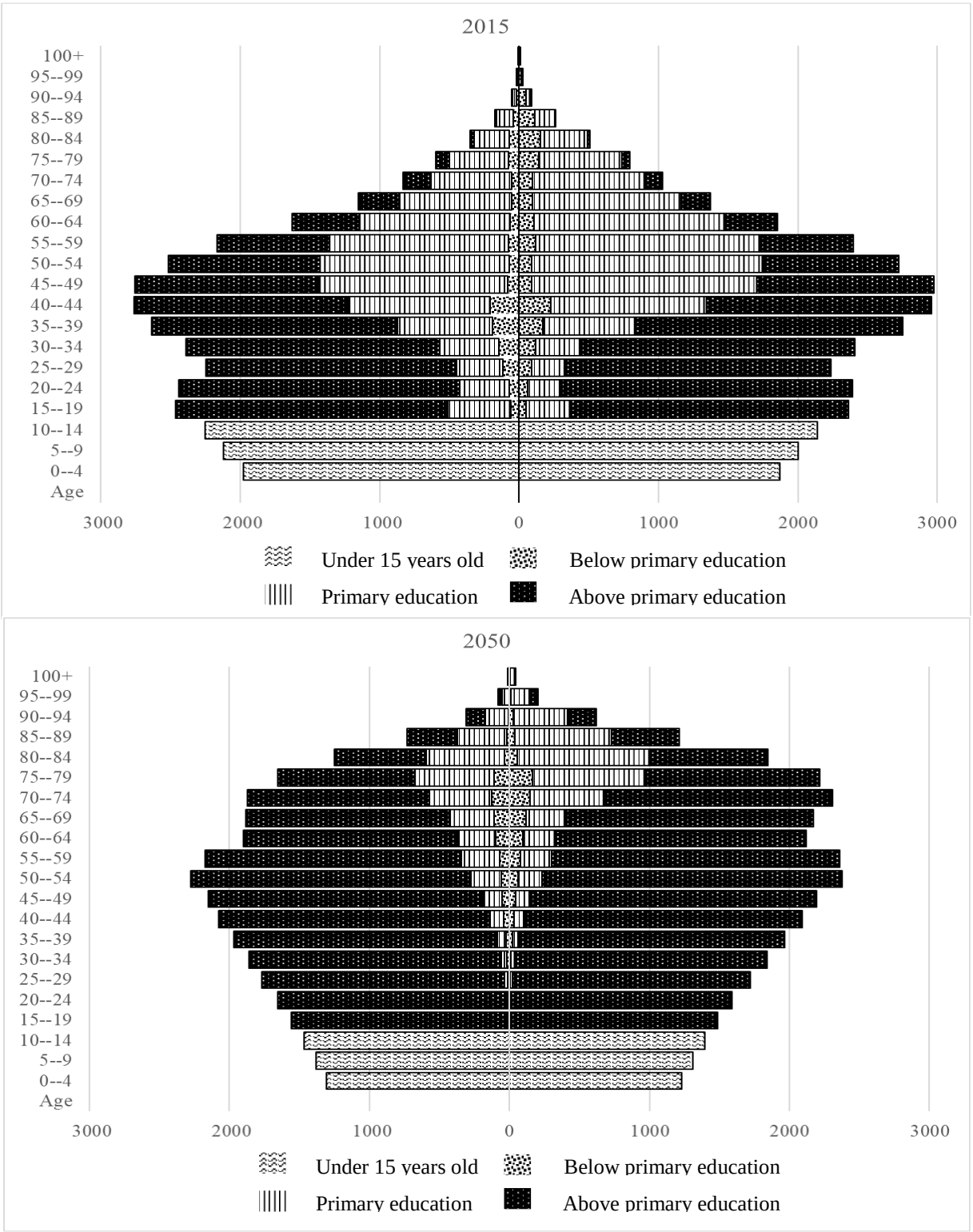
Table 4. 2: Education composition of persons aged at least 60 years (in percentage) total and by gender; Thailand, 2015 and 2050

	2015			2050		
	Total	Male	Female	Total	Male	Female
Less than primary education	10.7	7.9	13.0	5.2	5.2	5.1
Primary education	71.5	68.9	73.6	30.2	28.2	31.8
Above primary education	17.8	23.2	13.4	64.6	66.6	63.1

Source: Wittgenstein Centre for Demography and Global Human Capital, 2018. (Data accessed 20 January 2020)

In Figure 4.1, this differentiation in age and education composition of the population in Thailand is shown. The number of population in advanced ages increases in 2050. The education attainment of those in the younger age groups decrease but a great majority have higher education relative to those in older ages.

Figure 4. 1: Population pyramids for Thailand, 2015 and 2050, by education attainment.



Source: Wittgenstein Centre for Demography and Global Human Capital, 2018 (Data accessed on 20 January 2020)

4.4.2. Methods of analyses

In congruence with the aim of this study to estimate the effect of education on the cognition-adjusted dependency ratio relating to current and future population, other health indicators are presented here for comparative purposes. Health measures that have been shown to be associated with cognition are instrumental activities of daily living (IADL) (Burton, Strauss, Bunce, Hunter, & Hultsch, 2009; Gold, 2012; Reppermund et al., 2013) and depressive symptoms (Allerhand, Gale, & Deary, 2014; Jeste, Depp, & Vahia, 2010; Turner, Capuano, Wilson, & Barnes, 2015). IADL is primarily an indicator of physical dimension of health but involves mental faculties to be completed compared with activities of daily living (Dodge et al., 2005). Depression on the other hand is a representation of psychological functioning that has been observed to have a high degree of recursive co-morbidity with cognitive impairments (Turner et al., 2015).

There are multiple procedures done for this study and are presented in the subsequent four sub-sections.

4.4.2.1. Thresholds of poor health

A study by Skirbekk, Loichinger, and Weber (2012) analysed the variation of cognitive functioning as an indicator of ageing. They created a measure to distinguish those with good and poor cognitive performance. The ones with poor performance are those who had scored fewer than half the items in the cognitive test that they had used from the ELSA, HRS, and SAGE. With such an approach, they are able to compare

indicators from different areas using various survey instruments. For the present study, the comparison was done across time for Thailand. Another aspect to be noted is that the threshold of poor performance or poor health would have to depend on the health dimension, as it would be subsequently explored.

The central health dimension for this study is cognition. This is measured through the combination of recall and numeracy tests which represents what is called the principal cognitive function (Fleming et al., 2003; Grady & Craik, 2000; Singer et al., 2013). For the recall portion, a maximum of six points can be garnered while in numeracy, the maximum is two. Ultimately, the total score then is eight points signifying having responded correctly to all the cognitive test questions. The threshold for being unhealthy in this health dimension was when the respondent is able to answer equal or fewer than half of the items (Skirbekk et al., 2012).

IADL is based on three questions concerning the ability to take a bus, count money correctly, and taking medications completely and correctly (Knodel, Teerawichitchainan, & Pothisiri, 2018; Millán-Calenti et al., 2010; Rodakowski et al., 2014). For this measure, an individual having at least one limitation was deemed as bearing an unhealthy status (Knodel et al., 2018; Loichinger & Pothisiri, 2018).

Depression is within the psychological dimension of health and in this paper, it was measured through select symptoms (Butterworth, Rodgers, & Windsor, 2009; de Mello et al., 2013). Depression symptoms included are the feeling of having no hope in life, feeling unhappy, and feeling lonely. Similar to IADL, if an older person experienced at least one symptom, they were operationalised as unhealthy (Butterworth et al., 2009).

To obtain stable estimates for poor health, binary logistic regression was used as in previous studies (Batljan, Lagergren, & Thorslund, 2009; Loichinger & Pothisiri, 2018). Regression analyses were performed separately for males and females. Health measures were the dependent variables while the independent variables are age (categorised into five-year age groups starting with 60-64 years with the final category being 80 years and over) and education attainment (categorised into [1] Lower than primary education level, [2] Primary education and [3] Higher than primary education level). This regression model is as follows:

$$X(k)_i = \beta_0 + \beta_1 60\text{-}64_i + \beta_2 65\text{-}69_i + \beta_3 70\text{-}74_i + \beta_4 75\text{-}79_i + \beta_5 80\text{andover}_i + \beta_6 \text{primaryeduc}_i + \beta_7 \text{highereduc}_i + \varepsilon_i \quad (1)$$

Other covariates were initially used including income levels, residence, living arrangement, health behaviour, and social engagement to test if any of them were statistically significant with the health outcomes. Statistically significant factors are selected then predicted probabilities are calculated. These probabilities are held constant and are incorporated in the final regression model analyses to show the true effects on the association of education with health status factors.

4.4.2.2. Prevalence of ill health

The generated predicted prevalence rates of ill health will be applied to the population distribution. Due to the education-specific development between the

periods of analyses, direct standardisation is necessary as done by Loichinger and Pothisiri (2018) based on the method presented by Naing (2000). The predicted prevalence rates based on health measures in 2011, 2014 and 2016 when applicable. The standard population set for this study is the 2016 population structure by gender as computed from the 2016 PCWAS using sample weights.

For this part of the analysis, sex is accounted for in the regression models for predicted prevalence rates instead of being considered as overt classifications. Furthermore, two methods of standardisation are performed to show the effects of education. The standard population these analyses was based on the 2015 population. In the first methods, age- and sex-specific prevalence rates were estimated:

$$X(k)_i = \beta_0 + \beta_1 60\text{-}64_i + \beta_2 65\text{-}69_i + \beta_3 70\text{-}74_i + \beta_4 75\text{-}79_i + \beta_5 80\text{andover}_i + \beta_6 \text{male}_i + \varepsilon_i \quad (2)$$

In the next method for standardisation, education level was added to age and sex variables:

$$X(k)_i = \beta_0 + \beta_1 60\text{-}64_i + \beta_2 65\text{-}69_i + \beta_3 70\text{-}74_i + \beta_4 75\text{-}79_i + \beta_5 80\text{andover}_i + \beta_6 \text{male}_i + \beta_7 \text{primaryeduc}_i + \beta_8 \text{highereduc}_i + \varepsilon_i \quad (3)$$

4.4.2.3. Application of predicted rates to population projections

The age-, gender- and education- specific rates of poor health were applied to the population projections. The rates were multiplied with the population data to assess the effect of change that education attainment differentials have on older population with ill health. To have a point of comparison, a separate set of predicted prevalence rates were estimated with only age and gender in the logistic regression model.

4.4.2.4. Health-adjusted dependency ratio

In the traditional measure, OADR is calculated as:

$$\frac{P_{60+}}{P_{15-59}} \quad (4)$$

P_{60+} are those who are 60 years old and over and are considered as older persons; although in some cases, this is set at 65 years of age. $P_{15\text{-}59}$, of $P_{15\text{-}64}$, is composed of the working-age adults. There are novel approaches to determine dependency and this is done through integrating specific health dimensions (Muszyńska & Rau, 2012; Sanderson & Scherbov, 2010). For this study, the method formulated by Skirbekk, Loichinger, and Weber (2012) is used as it focuses on the older population while still considering those who are healthy and in ill health. In their paper, age variations in cognitive functioning is applied to old-age dependency ratio and defined the measure *cognition-adjusted dependency ratio*. This represented the ratio of older adults with lower cognitive performance to younger adults together with older adults who have

good cognitive functioning. This is adapted to the current study due to the data available in Thailand which has the age threshold of 60 years and encompasses the three health dimensions.

$$\frac{P_{60+,ill-health}}{P_{15-59}+P_{60+,healthy}} \quad (5)$$

The distinction between healthy and unhealthy is dependent on the nature of the health dimension. This is interpreted as the ratio of unhealthy older persons to all adults regardless of age.

4.5. Results

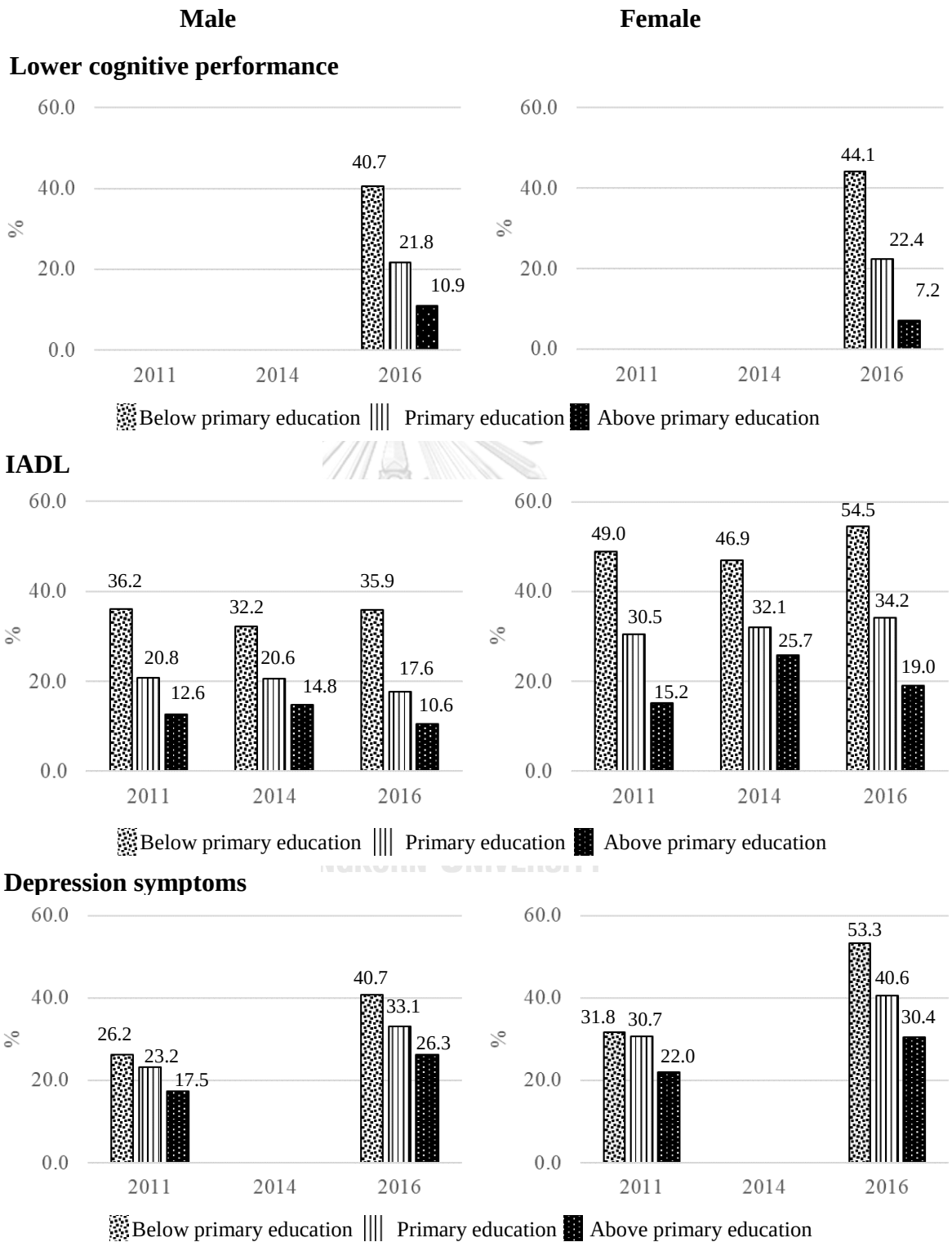
The first section (4.5.1) presents the predicted rates and how they manifest in the population by education differentials across the three periods of 2011, 2014 and 2016. Also included here is the prevalence rates by age group using the 2016 population as reference. The following section (4.5.2) includes the application of predicted rates to the absolute number of populations from the projections and also the resulting health-adjusted dependency ratios.

4.5.1. Poor health and education differentials

Based on the prevalence rates adjusted by age structure changes over time, ill health can be generally characterised as having negative association with education attainment (Figure 4.2). The degree of such an observation differs between health

indicators across the three time points. The advantage of those with increasing education attainment was evident in the prevalence of lower cognitive performance and IADL for both genders. Depression symptoms among both genders in 2011 was unique. There is little difference between having lower than primary education and having primary education. This changes in 2016 where the pattern becomes similar with the other health indicators.

Figure 4. 2: Prevalence of ill health status among persons 60 years old and above by gender and education, standardised for age; Thailand, 2011 to 2016



Sources: 2011 SOPT, 2014 SOPT and 2016 PCWAS

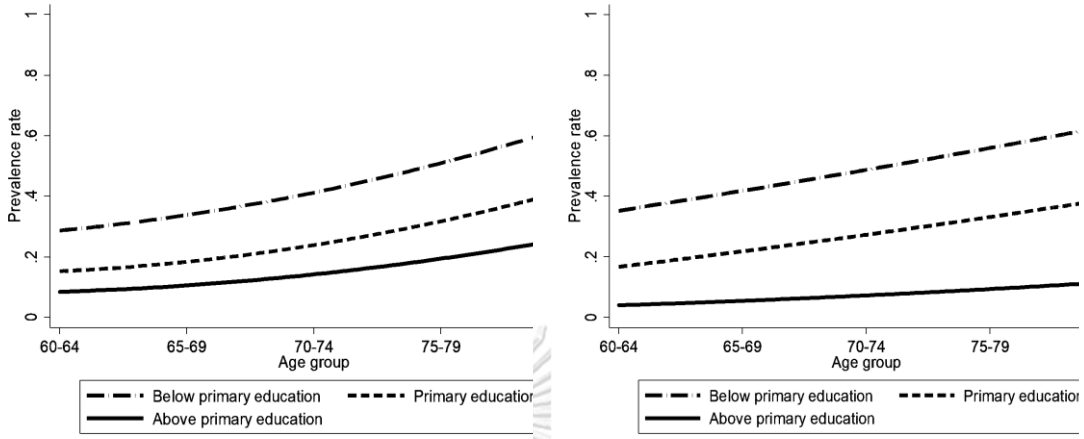
In another aspect of comparison, prevalence rates of IADL and depression were observed to be higher among women. The prevalence of poorer cognitive performance of women with higher than primary education on the other hand, is lower than that of males.

Figure 4.3 presents the interpolation of prevalence rates in 2016 to show the gradient by education for both genders. The figures of the prevalence rates are in Appendix 4.2. The education gradient in both genders is distinct for IADL and even more discrete for lower cognitive performance. Depression shows the gradient between the three education level classification but the increase to older ages is not apparent particularly among women. Such age trend was also observable in anxiety among males.

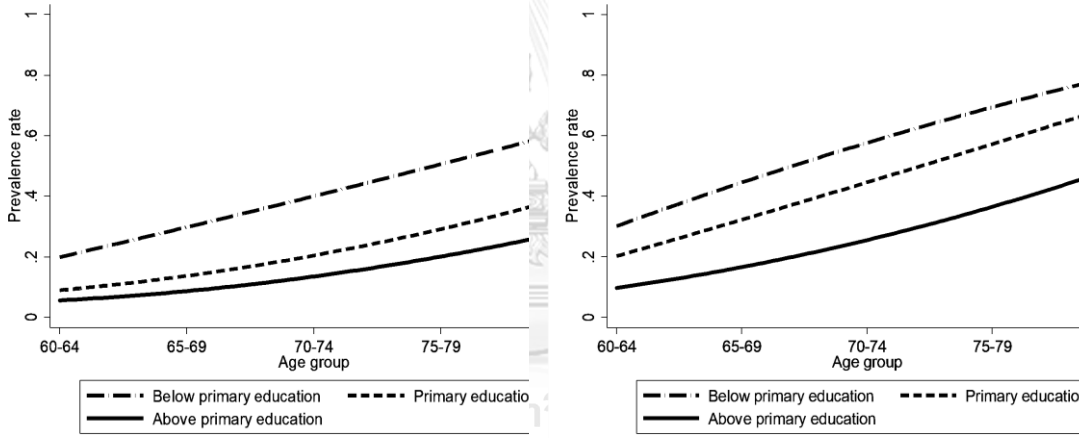
Figure 4. 3: Prevalence of ill-health status by age, gender and education, estimated by logistic regression; Thailand, 2016

Male **Female**

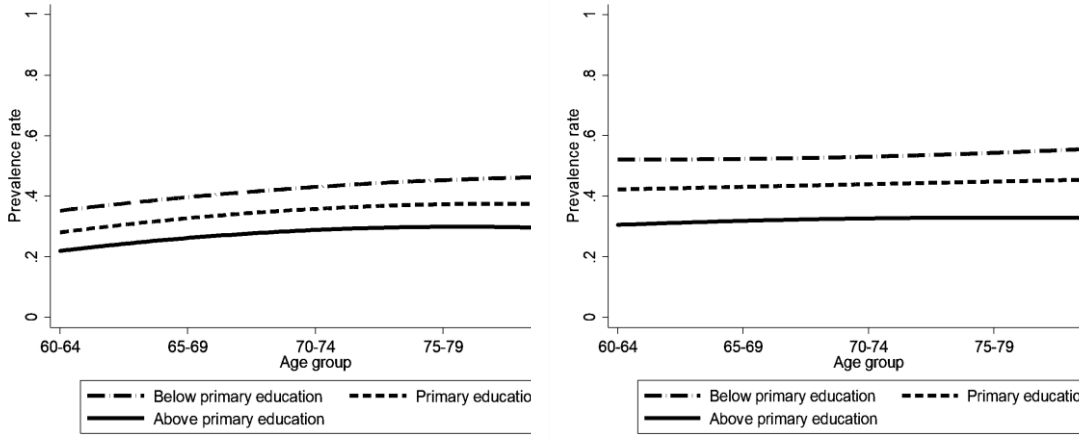
Lower cognitive performance



IADL



Depression symptoms



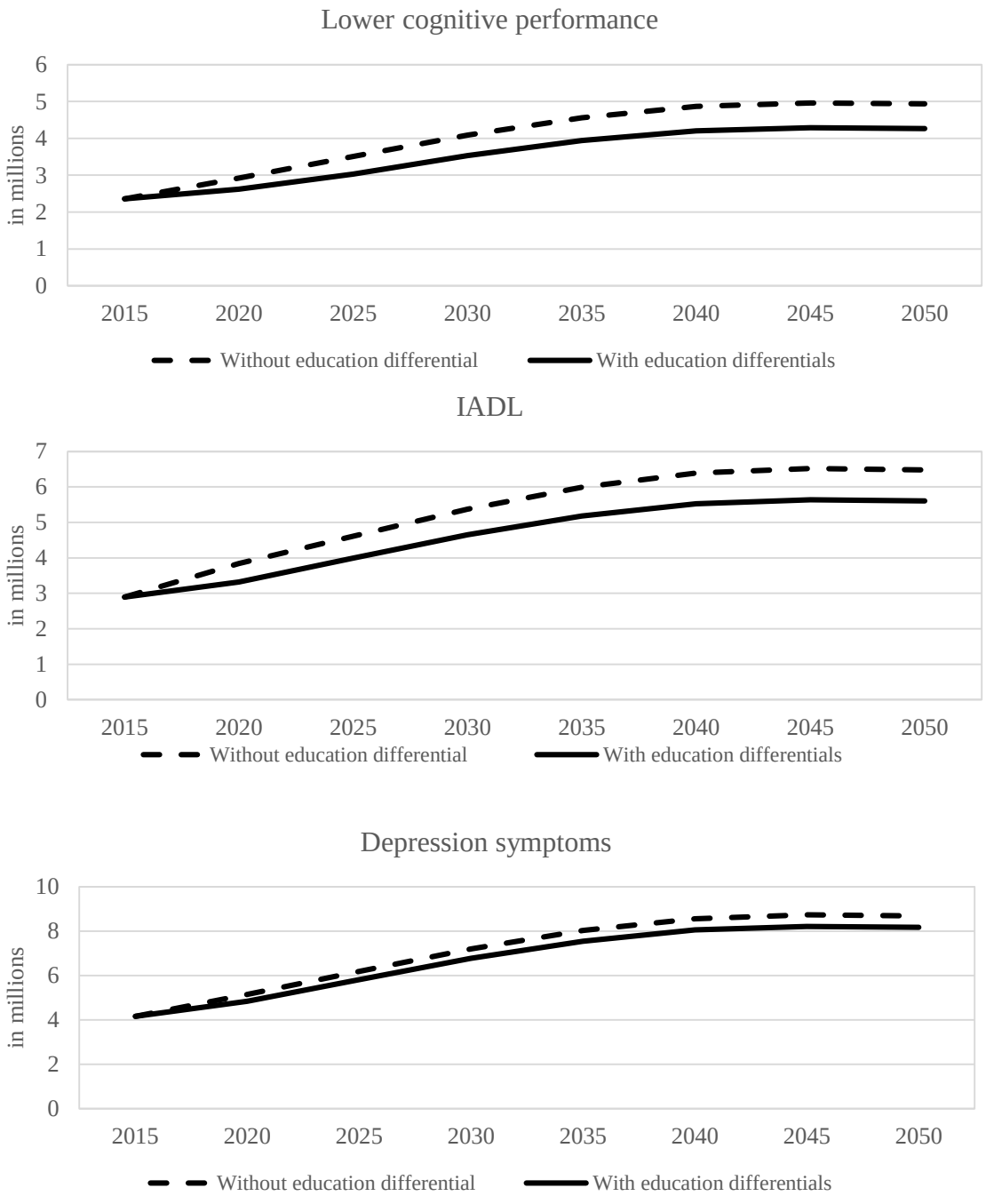
Note: Estimates were calculated from 2016 PCWAS

4.5.2. Population projections and health-adjusted dependency ratios

The development of prevalence rates for the health statuses across the three survey points do not exhibit a clear trend therefore only the ultimate survey point is used which is from the 2016 PCWAS. The predicted figures from a logistic regression model without education differentials and a model with education differentials are applied to the population projections (Figure 4.4). The aim here is to extract health-adjusted dependency ratios with reference to projected populations. As this is a ratio that is not differentiated by gender, the application of the populations with ill-health status is presented for the general population.

When education differentials are included as a factor in ill-health prevalence, there tends to be much lower rates compared with the population when no education differential is introduced. This is observable in IADL and lower cognitive performance although, the magnitude of difference for each health indicator is different. Again, the effect of education to depression is minimal.

Figure 4. 4: Number of persons 6o years and over with ill health status by type when performing the estimation with and without education differentials; Thailand, 2015 to 2050



Note: Results were estimated from 2016 PCWAS and the population projection from the Wittgenstein Centre for Demography and Global Human Capital, 2018 (Data accessed on 20 January 2020)

The proportion of older persons will continuously increase to 2050 given the development of the age structure across time (Table 4.3). This aspect of population growth leads to the stable increase of the traditional old age dependency ratio. From about 24 older persons for every thousand working-age persons in 2015, this figure will increase to almost 64 older persons in 2050.

Table 4. 3: Population projection by broad age groups and old age dependency ratio; Thailand, 2015 to 2050.

	Population aged 15-59 years (in thousands)	Population aged at least 60 years	OADR
2015	45575	10732	23.5
2020	44858	13281	29.6
2025	43451	15961	36.7
2030	41503	18596	44.8
2035	39477	20733	52.5
2040	37698	22108	58.6
2045	36334	22553	62.1
2050	35111	22434	63.9

Source: Wittgenstein Centre for Demography and Global Human Capital, 2018 (Data accessed on 20 January 2020)

Building on the utilisation of the prevalence rates with and without education differentials, the dependency rates based on each health indicator was also surmised. In Table 4.4, it is observed that the dependency ratios are significantly lower when education differentials are considered in the estimation process. Although depression has higher prevalence rates, the difference between estimates with or without education differentials is lower compared with IADL and lower cognitive performance.

Table 4. 4: Health-adjusted dependency ratio difference when performing estimations with and without education differentials; Thailand, 2015 to 2050

Year	Without education differential	With education differential	Difference between ratios (%)
	Lower cognitive performance		
2015	4.3	3.7	14.1
2020	5.8	4.5	22.9
2025	7.1	5.3	24.6
2030	8.4	6.2	26.3
2035	9.6	6.9	27.9
2040	10.5	7.5	29.0
2045	11.0	7.8	29.6
2050	11.3	7.9	29.9
	IADL		
2015	5.3	5.0	7.8
2020	6.5	6.1	7.9
2025	7.7	7.2	7.9
2030	9.0	8.4	8.0
2035	10.1	9.5	8.1
2040	10.9	10.2	8.2
2045	11.3	10.6	8.2
2050	11.6	10.8	8.2
	Depression symptoms		
2015	7.6	7.5	2.9
2020	9.3	9.1	2.9
2025	11.1	10.9	3.0
2030	13.0	12.7	3.0
2035	14.6	14.4	3.1
2040	15.9	15.6	3.1
2045	16.6	16.3	3.1
2050	16.9	16.6	3.1

Note: Results were estimated from 2016 PCWAS and the population projection from the Wittgenstein Centre for Demography and Global Human Capital, 2018 (Data accessed on 20 January 2020)

The effect of education differential being part of estimation is substantial for cognition. The dependency ratio for those with poor cognition is 14 per cent lower in 2015 when education differential is utilised than when it is not. This figure in difference between with and without education differential becomes almost 30 per cent whereby there are 8 older persons with poor cognition for every 1000 working-age adult along with healthy older adults in 2050 compared with about 11 older persons with poor cognition in the year 2050.

4.6. Discussion

As the proportion of older persons in Thailand continues to increase according to projections, there is a commensurate increase in the ratio of old-age persons with ill health. From 2015 to 2050, the people at least 60 years old with issues with their physical, psychological, or cognitive health will increase to twice of current figures. This will have an impact on healthcare delivery for society because there are various concerns on palliative and long-term care. Delving further into this, it is key to understand the nature of the prospective concerns surrounding health whereby disabilities can be of different forms.

Longer life expectancies are observed but with it is the attention to its quality. The concept of healthy, successful age advancement then had been integrated into ageing studies. A stereotype is assigned to older persons where they are viewed as being overtly vulnerable to diseases and disabilities leading to higher levels of dependency in most aspects of everyday life (Villar, 2012). With regard to successful ageing, the characteristics are modified because older persons can be of low risk to

diseases, be highly functional in terms of physical, cognitive, and mental standpoint; and be able to engage and to have a prosperous relationship with others. A number of these successful ageing studies regarding health are on physical activities and the presence of non-communicable diseases as the data is accessible from medical records, surveys, and clinical studies (Hankinson et al., 2010; Porapakkham, Pattaraarchai, & Aekplakorn, 2008; Reiner et al., 2013). As noted by Chatterji and colleagues (2015), cognitive functioning and health of older persons tend to have sparse data even among high-income countries.

Dependency as a concept has to be viewed from a multidimensional perspective. The dependency ratios based on health dimensions, which are physical, cognitive, and physical, have to be scrutinised as observed in the result as they may bear different levels of burden among the older population. If health rates are held constant, it is observed that cognitive functioning will need increased attention toward the future. The dependency using cognitive health aspect as reference is much higher than the other health dimensions. Although, the other health aspects would also have to be addressed. Each person can have a range of limitations whereby each one may affect the others i.e. having physical difficulties can affect depressive symptoms or have less cognitive functioning (Christensen et al., 2013). Understanding the nature of older people's health therefore, has to be holistic.

Socioeconomic factors also have to be considered toward the understanding of dependency among older people. Education was observed here to have a positive impact toward better health of the older population which is congruent to the literature (Batljan et al., 2009; KC & Lentzner, 2010; Sanderson & Scherbov, 2014). The manifestation of this effect of education may be due to the prevailing health-related

behaviour, particularly regarding food choice and intake, which can change through time and therefore be transmuted to differences in impact on the older population (Baker et al., 2017; Porapakkham et al., 2008).

As it has been presented in the results, there is particular gap between the use of traditional and novel measures on the older population especially for future populations. The use of OADR vis-à-vis the health-adjusted dependency ratio such as the CADR had shown the limitations of the former as it only pertains to the notion of economic dependency (Sanderson & Scherbov, 2015). The importance of using human capital, which is subsumed by education and health, to mark the development of a population in the future had been highlighted in the literature (Lutz, 2009, 2010; Lutz, Goujon, & Wils, 2008). The increase in schooling of children has to be considered a near-term investment in order to gain the benefits in the long-term as it had been presented in the projected prevalence rates of ill health in this thesis. On the other hand, the use of a novel measure such as CADR also shows the prospective issues of the older population in the foreseeable future which has utility in terms of formulating policies (Loichinger & Pothisiri, 2018).

Increasing education levels have societal benefits, but studies (Lutz, 2009; Lutz et al., 2014; Lutz et al., 2018) had also emphasised the quality of the content of education has to be guaranteed. Lutz (2009) stressed that universal schooling is important but the aim also has to be personal and mental empowerment. This empowerment can also be achieved by current older persons through lifelong learning (Lutz, 2019). This is the reason policies have to be responsive and relevant to the needs of contemporary older people and future older populations

4.7. Highlights

- The prevalence rate of ill-health statuses decreases as education level increases.
- Applying current health prevalence rates to population projections, it was observed that education attainment significantly decreases the prevalence of ill health in the future.
- By integrating health and education into the traditional old age dependency ratio, the level of dependency of the future older population of Thailand decreases.
- The disparity brought on by social gradient was observed to create differences in prospective care needs.

Chapter 5: Characteristics Approach to Cognitive Ageing [3]

5.1. Overview

As observed in Chapter 3, the human capital factors of education and income were observed to be associated with cognitive ability. And in the preceding chapter (4), the novel approach of integrating health and education with the traditional old age dependency measure was performed. A similar aim of using a novel approach, the characteristics approach, is performed in this present chapter. In the characteristics approach, education and income levels as sub-groups are utilised to differentiate the speed of cognitive ageing among older men and women.

5.2. Introduction

Ageing is a process that is affected by multifarious factors and it has to be approached in commensurate manner. This multidimensional perspective was presented by Sanderson and Scherbov (2013) through the introduction of age-specific characteristics that can vary over time and between societies. The framework integrates the characteristics of people with varying units into a common one in the

[3] The texts, tables and figures presented in this chapter have been adapted from the following paper:
Vicerra, P. M. M., & Pothisiri, W. (2020b)Trajectories of Cognitive Ageing among Thai Later-Life Adults: The Role of Education Using the Characteristics Approach. Journal of Population and Social Studies. Some terminologies had been changed to attain consistency in the present thesis.

form of comparable years of age or the ‘alpha-ages.’ This characteristics approach has been applied previously on characteristics as hand-grip strength and chair rise speed (Sanderson & Scherbov, 2010; Sanderson et al., 2016).

Differentiating functioning and capacity among these persons is often done between societies but comparing individuals within a society is appropriate to gauge how much they are affected by variations in education attainment. This is done through the characteristic ageing approach which takes the population of people according to specific subgroups because of varying rates or paces of the ageing process (Sanderson & Scherbov, 2013, 2014). The aim of this chapter is to analyse differences in the speed of cognitive ageing regarding cognitive ability among people 60 years and above in Thailand.

This chapter presents the application of the characteristics approach to cognitive ageing to estimate the differences in the speed of ageing between education and income levels. It begins with an introduction (5.2); the presentation of the research questions (5.3), then the methodology (5.4); followed by the results (5.5), and subsequent discussion (5.6), then finally, the highlights of the results are summarised (5.7).

5.3. Research questions

This chapter continues from the initial observation that education and income have a strong association with cognitive function of older persons. A deeper understanding of the cognitive ageing process is presented here by estimating its speed of decline which will differ because of the suggested benefits of having better

education and also better income. The specific questions that are addressed in this section of the thesis are:

1. How different are the levels of cognitive performances of men and women with varying socioeconomic factors of education and income levels?
2. How much does certain levels of education and income affect the speed of decline in cognitive functioning among males and females?
3. Between education and income, which socioeconomic factor produce greater differences in cognitive ageing?

5.4. Methodology

The following are described in this section: data and sample (5.4.1), the operationalisation of cognitive function (5.4.2), and the method of analysis (5.4.3).

5.4.1. Data and sample

This section presents the data and analytic sample used for this study within this research. More detailed information on the following had been presented in sections 3.4.1 and 3.4.2.

This study utilises the 2016 Population Change and Well-being in the Context of Aging Society (2016 PCWAS). The 2016 PCWAS was conducted by the College of Population Studies, Chulalongkorn University which addresses two related matters

with regard to the structure of the population of Thailand: reproductive health and ageing. For each of these, exclusive questionnaires are implemented whereby in the former, females aged 15 to 49 years were considered for sampling and in the latter, both genders aged at least 60 years are taken as samples. Data collection was done through face-to-face interviews.

Sample units were selected through a four-stage clustered probability sampling method (College of Population Studies, 2018). The first stage is the designation of five areas as strata: Bangkok, Central (excluding Bangkok), North, Northeast, and the South. Five provinces were selected in each of the regions except Bangkok resulting to a total of 20 provinces and Bangkok metropolis. The second stage is gaining a sampling list of districts. Each province is listed with 50 districts while Bangkok is divided into two (2). The third stage is classifying each stratum to 100 enumeration areas (EA's) and through Probability Proportional to Size system of sampling, EA's will be identified where the maximum number of EA's is seven in a given district. Finally, households are selected whereby 30 households are identified for each EA totalling 15,000 households. Households are defined by the project as a home where at least one person resides and necessitates living. In the case of multiple persons in a dwelling, relatives and non-relatives may be co-residing and still be considered a single household.

For the analyses in this study, the sample was limited to 7,450 persons aged 60 and older. Because all measurements of physical and psychological health adopted in the study are subjective and self-reported, further restriction on the sample was applied to individuals who responded to the survey without assistance from others, and provided valid responses to all questions used in the analysis. Relative to the total

older adult sample, cases with proxy respondents account to 2.1 per cent and those with missing data account for 13.3 per cent. With all these restrictions, the analytic sample size comprises 6,301 older persons.

Sample restrictions may limit generalisation of findings to all persons aged at least 60 years. Diagnostic analyses then were done between the complete and the analytic sample among males and females. No statistical difference was observed in cognition scores of the said samples for both genders. Analyses were also done for select demographic and socioeconomic characteristics particularly age, marital status, education, and average annual income. No statistical difference for complete and analytic samples was observed among males and females.

5.4.2. Operationalisation of cognitive function

The cognitive function index is constructed based on aggregated scores from two significant domains of cognitive health: memory and numeracy (Fleming et al., 2003; Grady & Craik, 2000; Trott et al., 1999). Memory is assessed through two tasks involving word repetition and recall. In the survey, respondents were instructed to listen carefully to three unrelated Thai words (translated as tree, car and hand) and to repeat these words, in any order, immediately afterwards. One point was given for each correct answer. Respondents were then instructed to memorise these three words and to recall them after completing the subsequent numeracy task. Likewise, one point was given for each correct answer, irrespective of recalled word order. In total, a maximum score of six points was given.

Numeracy was assessed through serial-7s or ‘sevens’ subtraction task. Respondents were asked to assume that they initially had 100 Thai baht and provide the leftover amount after spending seven baht. If the answer was correct, respondents were asked further to provide the leftover if another seven baht was spent. One point was given for a correct answer at each step, with a maximum score of two. This task was adapted from the Mini-Mental State Examination (College of Population Studies, 2018) by describing the questions in terms of a money transaction and was observed by the survey team to improve respondents’ understanding of the questions.

The scores from the two measures were totalled to create the cognitive function index, which ranged from 0 to 8. Higher index scores indicated better principal cognitive function. As indicated by the reliability coefficient, i.e. Cronbach’s alpha (0.62), memory and numeracy are acceptable components of the cognitive function index (Hinton et al., 2014).

5.4.3. Method of Analysis

The information on characteristics for this study will be utilised to measure alpha-ages. These α-ages are characteristic ages whereby people who have the same α-age have the same characteristic. The framework then begets the *C(.)* which is the characteristic schedule such that the chronological ages are attributed to a specific characteristic.

$$k = C_r\,(a), \qquad (1)$$

where *k* is the level of characteristic as cognitive functioning that is observed at age *a* following the characteristic schedule *r*.

Subgroups are represented by the latter index *r*. It represents the group within the population which the characteristic is being measured. When this characteristic schedule is to become monotonic, α-ages are derived in this manner:

$$\alpha = C_s^{-1}\,(C_r(a))\,, \qquad (2)$$

such that α is the alpha-age corresponding to chronological age *a* within characteristic schedule *r* with a standard characteristic schedule *s*. Therefore, an alpha-age at the standard schedule is the chronological age that corresponds to the other chronological age within the *r* schedule. To exemplify, a characteristic level of 100 is set and in the standard schedule, the chronological age group that has such a level are those 60 years old. But for those following the characteristic schedule *r* the group that possesses the same characteristic level are those aged 65 years (Sanderson et al., 2016).

Expanding on alpha-ages subsequently being able to utilise it for cross-section or longitudinal data, specific modelling has been formulated and detailed in some studies (Sanderson & Scherbov, 2014; Sanderson et al., 2016). The said model's fundamental tenet applied to health outcomes is as follow:

$$X_i = \beta_0 + \beta_1 age_i + \beta_2 Y_i + + \varepsilon_i \qquad (3)$$

The dependent variable *X* is the health characteristic of person *i*. The independent variables are *age* and *Y*, which represents a characteristic of person *i*. In Sanderson's and Scherbov's study (2014), the outcome was hand-grip strength and the independent variables apart from age^2 are height and weight which was based on the literature. By using this model, the outcome becomes interpretable using the characteristics approach which refers to alpha-ages vis-à-vis the standardised characteristics schedule.

$$X(k)_i = \beta_0 + \beta_1 age_i + \beta_2 primaryeduc_i + \beta_3 highereduc_i + \beta_4 higherinc_i + \varepsilon_i \quad (4)$$

The model applied for this current study determines the cognitive performance, k, by different levels of education. Education has three categories: (1) no education and below primary level, (2) primary level which is 4^{th} to 6^{th} grades, and (3) higher than primary level. The reference term is category (1) for education. Income is a correlated socioeconomic factor with education and is operationalised as a two-quantile variable: lower and higher income levels. It was used as a control in order to show the true effects of education toward the outcome. Multicollinearity tests were done to due to the often highly correlated nature of the independent variables. Analysis of variance have also been utilised to compare the means between sexes for each factor whereby the significance level is set at $p < 0.01$.

Another model is used toward understanding cognitive ageing by income levels while controlling for education. The equation model for this is:

$$X(k)_i = \beta_0 + \beta_1 age_i + \beta_2 middleinc_i + \beta_3 highinc_i + \beta_4 higheduc_i + \varepsilon_i \quad (5)$$

Income in this model is categorised into tertiles: (1) Low, (2) Middle, and (3) High. Education is redefined into a dichotomous variable between those who have primary education level of 4th grade and lower; and those who have higher than primary education level.

The following equations are used to determine linear change in cognitive performance through the α-ages by education subgroup:

$$\alpha_{k,\text{primaryeduc}} = \frac{\text{age}_{\text{noedu}} - \hat{\beta}_2}{\hat{\beta}_1} \quad (6)$$

$$\alpha_{k,\text{highereduc}} = \frac{\text{age}_{\text{noedu}} - \hat{\beta}_3}{\hat{\beta}_1} \quad (7)$$

α-ages by income subgroups are from the following equation models:

$$\alpha_{k,\text{middleinc}} = \frac{\text{age}_{\text{lowinc}} - \hat{\beta}_2}{\hat{\beta}_1} \quad (8)$$

$$\alpha_{k,\text{highinc}} = \frac{\text{age}_{\text{lowinc}} - \hat{\beta}_3}{\hat{\beta}_1} \quad (9)$$

Due to the correlation of education and income, the interaction between the two socioeconomic factors was tested in the model such that the operationalised dichotomous variables were used. In Table 5.1, the results of the regression analyses for males and females are shown.

Table 5. 1: Association of the interaction of education and income on cognitive performance among older Thais by sex

	β	SE	p-value
Male			
Higher than primary level	0.399	0.171	0.020
Higher income level	0.383	0.095	0.000
*(Education) * (Income)*	0.112	0.193	0.563
Female			
Higher than primary level	0.667	0.153	0.000
Higher income level	0.264	0.081	0.001
*(Education) * (Income)*	0.194	0.176	0.271

**Models for each sex controlling for age variable*

Due to the lack of statistical significance of the interaction term between education and income variables, a sub-grouping of the sample is performed to see how much difference income levels have while still considering education. The equation form for this model is:

$$X(k)_i = \beta_0 + \beta_1 age_i + \beta_2 LEHI_i + \beta_3 HELI_i + \beta_4 HEHI_i + \varepsilon_i \qquad (10)$$

Four groups were generated which are those with: (1) lower education with lower income [LELI]; (2) lower education with higher income [LEHI]; (3) higher education with lower income [HELI]; and (4) higher education and higher income [HEHI]. The equation for the linear changes with α-ages by education-income subgroups are:

$$\alpha_{k,LEHI} = \frac{age_{LELI} - \hat{\beta}_2}{\hat{\beta}_1} \qquad (11)$$

$$\alpha_{k,HELI} = \frac{age_{LELI} - \hat{\beta}_3}{\hat{\beta}_1} \qquad (12)$$

$$\alpha_{k,HEHI} = \frac{age_{LELI} - \hat{\beta}_4}{\hat{\beta}_1} \qquad (13)$$

The first category of having lower education and lower income is the reference for the regression model to determine the α-ages.

5.5. Results

Education and income between males and females aged at least 60 years old were dissimilar (Table 5.2). The average age regardless of sex in the sample was 68 years. Fewer females at 12% achieved higher than compulsory level of education compared with males at about 23%. In conjunction, half of the females gain low level of monthly income from various sources while it was around 40% among males.

Table 5. 2: Population of males and females aged 60+ years by education and income, Thailand, 2016

	Male	Female
Education attainment		
Lower than primary level	11.8	18.6
Primary level	65.3	69.2
Higher than primary level	22.9	12.3
Income		
Low	41.4	50
Middle	26.3	25.9
High	32.3	24
Total	2611	3690

Source: 2016 PCWAS

Comparing the means of proportions of principal cognitive function by education and income, it was observed that there was higher disparity in cognitive function if disaggregated by the former (Table 5.3). Those with no education among males and females had an average capacity of 69% and 65% respectively. Older persons with higher levels of education had cognition functioning score at 86% or

above. A similar pattern was observed with disaggregation by income although the difference is smaller.

Table 5. 3: Proportion means of principal cognitive function by education and income among older Thai males and females

	Male		***Female***	
	Mean	(95% CI)	Mean	(95% CI)
Education level				
Lower than primary	0.6984	(0.6617 - 0.7352)	0.6614	(0.6353 - 0.6875)
Primary level	0.7921	(0.7797 - 0.8046)	0.7787	(0.7685 - 0.7889)
Higher than primary	0.8640	(0.8474 - 0.8806)	0.8809	(0.865 - 0.8967)
Income				
Low	0.7482	(0.7297 - 0.7666)	0.7312	(0.7172 - 0.7453)
Middle	0.8055	(0.7871 - 0.8239)	0.7911	(0.775 - 0.8072)
High	0.8543	(0.8415 - 0.8672)	0.8254	(0.8091 - 0.8417)

Source: 2016 PCWAS

Corresponding ages according to cognitive function scores is one of the strengths of the alpha-ages based on the characteristics approach. The lower than primary level of education was considered the standard to view its hypothesised advantage relative to those with higher levels of attainment. The comparisons between the performance of older persons with regard to cognition are presented in Table 5.4.

Table 5. 4: α-ages of cognitive performance for older males and females by education.

Reference Age *(Lower than primary education level)*	**Male**		**Female**	
	Primary education level	*Higher than primary education*	*Primary education level*	*Higher than primary education*
60	67.7	69.5	65.7	67.2
65	71.1	72.8	69.8	71.4
70	74.4	76.1	73.9	75.5
75	77.7	79.4	78.0	79.6
80	81.4	83.1	82.3	84.0

Note: Results were estimated from 2016 PCWAS

Among both sexes, there was an increasing advantage in cognitive ageing with increasing levels of education attainment. The level of performance in cognition among persons aged 60 years with lower than primary education was similar to that of those at about 68 and 70 years among those with primary level of education and higher than primary level respectively. As they grow older in age, the differences lessen but the advantage of higher than primary level of education remained. There was about a 3-year difference in cognitive ageing compared with those who have lower than primary education while there was almost one year of difference with those who have primary level of education.

The similar pattern was observed among older females although the difference was smaller. The age difference of women with lower than primary education against those with the primary level and higher than primary level was 6 and 7 years respectively. In spite of this, another varying observation with males was that the decrease in performance among females as they age is lower such that comparing with the reference age of 80 years. Women with primary level of education had the

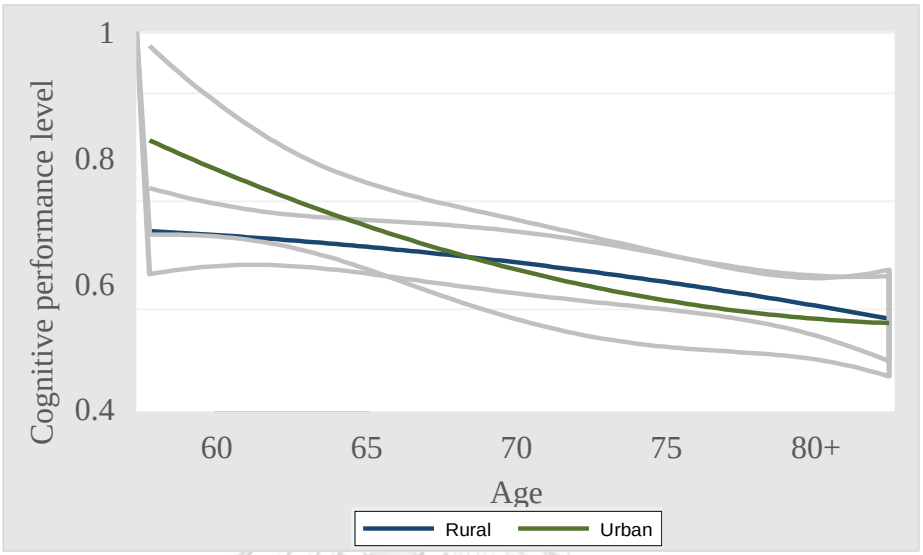
same performance when they are 82 years old and women with higher than primary education had the same cognition performance at age 84 years.

Selectivity by characteristics of the sample may have taken place because the social environment may contribute to the manifestation of differences in cognitive functioning. It can be argued that persons with higher levels of education attainment tend to reside in urban areas (Knodel, Teerawichitchainan, Prachuabmoh, & Pothisiri, 2015). Also, being in the urban area can offer more avenues among older persons to be exposed to physical environment requiring more focus and attention as vehicular traffic; as well as being exposed to more economic and social activities (Buffel, Phillipson, & Scharf, 2012).

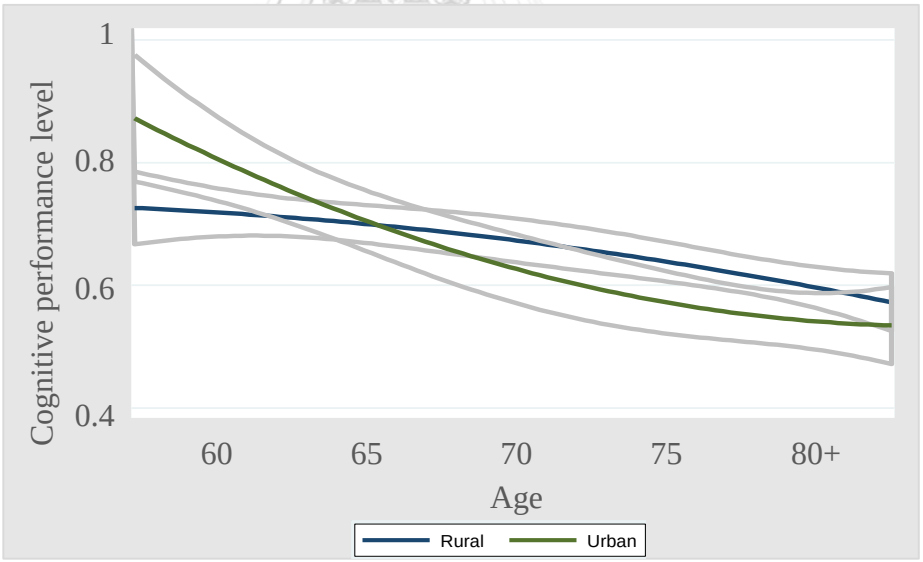
When comparisons were done between those lacking in education in the rural and urban areas to determine if this had a role, it was observed that there was no difference in cognitive functioning. In Figure 5.1, spline interpolation was used to present the speed of cognitive ageing by specific functions wherein the cognition scores were treated as functions of age. The curves of cognitive functioning scores for both sexes with lower than primary education by location of residence were not statistically different.

Figure 5. 1: Cognitive performance among those with lower than primary education level by residence with 95% cognitive interval

A. Male



B. Female



Note: Results were estimated from 2016 PCWAS

In Table 5.5, Cognitive ageing by income subgroups is presented.

Table 5. 5: α-ages of cognitive performance for older males and females by income, Thailand 2016

Reference Age (Low income level)	**Male**		**Female**	
	Middle level	*High level*	*Middle level*	*High level*
60	61.4	63.3	62.2	64.5
65	66.4	68.1	67.1	69.2
70	71.3	72.9	71.9	73.9
75	76.2	77.7	76.8	78.6
80	81.1	82.5	81.6	83.4

Note: Results were estimated from 2016 PCWAS

The gradients in cognitive performance by age among those with higher education attainment was pronounced among men and women but it is higher for the latter. There was about 5-year difference for women with high income level compared with males who had a difference of around three years. The gradients decrease through age similar to what had been observed when using education subgroups. Although, education subgroups indicate higher differentials in age in general than income subgroups.

Table 5. 6: α-ages of older males and females by education-income groups.

Reference (LELI)	LEHI	HELI	HEHI
Male			
60	61.7	64.4	65.2
65	66.6	69.0	69.8
70	71.4	73.7	74.3
75	76.3	78.3	78.9
80	81.1	82.9	83.5
Female			
60	63.0	65.2	66.4
65	67.8	69.8	70.9
70	72.5	74.4	75.3
75	77.3	78.9	79.8
80	82.0	83.5	84.3

Note: Results were estimated from 2016 PCWAS

Comparing with male LELI, there was a 1-, 4-, and 5-year difference with those who have LEHI, HELI, and HEHI respectively. The performance gradients through increasing ages decreased such that there was 1-year difference between LELI and LEHI at age 80 years; while there was about 4-year difference between LELI and HEHI at the same age. A similar pattern was observed among females. What was different among women was that the α-ages were slightly higher than that of the results for men.

5.6. Discussion

Distinguishing effects by certain characteristics, such as race, toward cognitive function has been observed in other societies as the U.S. (Cagney & Lauderdale, 2002). In this chapter, the prevalence of lower cognitive performance varies greatly between with regard to sex. This observed difference in speed of cognitive ageing

aspects bears similarities with the case of Latin America and the Caribbean where differences from early life until advanced ages (Maurer, 2011). The difference may be brought about by biological and social factors. This biological effect has been suggested in the literature to be from chromosomal and hormonal aspects (Mielke et al., 2014; Petersen et al., 2010). Such an effect from biology may be connected with the longevity of life among women compared with men therefore their propensity to experience cognitive issues is higher and more severe (Mielke et al., 2014).

With regard to social aspect of cognitive decline, the benefit of higher than primary level of education is higher among women as observed in this paper. This is assumed in the theory of resource substitution whereas it is expressed that lacking in one resource is recompensed in another (Ross & Mirowsky, 2010). In the current country setting, as women have less resource with regard to income and societal power in the Thai situation, the effect of education is magnified.

In another aspect of this study, it has been observed that education and income bring about variations in speed of cognitive ageing although the former has a larger effect. This agrees with the general observation that higher levels of education have a positive cognitive function outcome (d'Uva et al., 2008; Richards & Sacker, 2011).

There have been studies over the years that gauge the degree to which education and income may impact health (Cutler & Lleras-Muney, 2006, 2010, 2012; Schnittker, 2004). The general observation is that both socioeconomic factors have a positive association with health outcomes but it is education that has a stronger effect (Cutler & Lleras-Muney, 2010; Herd, Goesling, & House, 2007; Piha, Laaksonen, Martikainen, Rahkonen, & Lahelma, 2010). It is expounded that education has continuity in its effect that it can influence life chances, opportunities, and activities

until much advanced ages (Schöllgen et al., 2010). Income on the other hand does not have this continuity effect and that income in itself is not indicative of the financial situation of later-life adults (Huisman, Kunst, & Mackenbach, 2003; Schöllgen et al., 2010).

The effect of education had been suggested to be brought on by general conditions in early life such as better access to health care as well as having better health behaviour as individuals as well (Cutler & Lleras-Muney, 2006). This finding of the differentials brought forth by education is coherent with the cognitive reserve framework (Weber & Skirbekk, 2013; Zahodne, Stern, & Manly, 2015) whereby people with higher levels of education mentally process tasks more efficiently through life subsequently delaying cognitive ageing or even impairment.

Rather than maintaining the focus on the single characteristic of chronological age, a multidimensional perspective on cognitive ageing was explored in this study. The experience of cognitive ageing has variation among people within a population. Education and income, as observed in this study and also in the general literature, shows that there are gradients to cognitive decline. The advantages of increased education level among people with regard to their cognitive performance during older ages should be considered in investing in the education of younger populations. This near-term investment in population development has long-term gains for the population.

5.7. Highlights

- The process of ageing has to be viewed as diverse among people within a population.
- Higher education and income levels provide advantages to the process of cognitive ageing for both men and women.
- The benefit of education was higher among males and greater advantage among females when income levels are considered.
- The difference in α-ages among females tend to have a smaller decline when they grow older.

Chapter 6: Conclusion and Implications

6.1. Overview

In this concluding chapter, the findings were integrated and several implications were drawn. Presented in the following sections are a brief review of the thesis (6.2), limitations of the research (6.3), and the recommendations (6.4).

6.2. Review of thesis

The different ways which cognitive ageing varies depending on education level has been the theme of this thesis. Education has been consistently observed to have association with cognitive functioning. By utilising different methods to analyse the association and effect of education on cognitive ageing, different modalities are identified as (1) covariates of cognitive ability, (2) present and prospective prevalence of lower cognitive performance, and (3) characteristics approach to cognitive ageing.

6.2.1. Covariates of cognitive ability

This analysis that was presented in Chapter 3 aimed to determine if education and other demographic and social factors were associated with cognitive performance. Furthermore, it sought to determine if the factors associated with the outcome is similar between men and women given differences in biological and social context of each gender (Lin et al., 2015; Meng & d'Arcy, 2012; Voss et al., 2010). The analytic method applied was the Poisson regression model where the outcome variable is the

cognitive function index. This index of cognitive ability is based on the primary cognitive function comprised of memory and numeracy (Fleming et al., 2003; Grady & Craik, 2000; Trott et al., 1999).

The association of education level with cognitive function are observed to be consistent for older Thai men and women. Another socioeconomic factor found to have a consistent association with higher cognitive function was higher income levels. The difference in results was observed among males where factors on co-residence, health behaviour and select social engagement were observed to be associated. The experience of physical limitation and depressive symptoms also differ in association such that the former was observed among men and the latter is observed among women.

Education and income are individual attributes that had been found to be associated with better cognitive performance in older ages (Bajaj et al., 2013; Skirbekk et al., 2012; Weber & Skirbekk, 2013). Better human capital factors allow individuals to access healthcare services as in the case of Thailand (Quashie & Pothisiri, 2019). Also, having more resources allows older people to engage in leisure or lifelong learning activities that allow for mental stimulation and socialisation opportunities (Seinfeld et al., 2013; Tesky et al., 2011).

Physical and psychological health indicators demonstrated different impacts on men and women. The explanation for this difference was not evident in this study. On the other hand, co-residence which had been found to be significantly associated with cognitive performance among males may be related to the observation in Belgium (Mazzuco et al., 2017) whereby men tend be dependent on people around them in the household and therefore their health status remains at a better level.

6.2.2. Present and prospective prevalence of lower cognitive performance

In chapter 4, the prevalence of lower cognitive performance was estimated. To have a comparative perspective on the magnitude of the said prevalence of ill health, other health dimensions were included in the analyses namely limitation in instrumental activities of daily living and having depression symptoms. The estimated prevalence rates were analysed by creating models where education differentials were applied to current and future populations to observe their effects on health status. The definitive aim of this section was to determine how many within the older population would be in good health and those who have health limitations; whereby the latter can be indicative of those who may need care.

It was observed that there was a positive education gradient across all health indicators. Integrating age-, gender-, and education-specific prevalence rates for each indicator with population projections, lower figures of persons with ill-health status were observed relative to the figures observed using the approach that only considers age and gender. These findings are in conjunction with previous studies that education levels influence health outcomes involving economically developed countries (Batljan et al., 2009; KC & Lentzner, 2010) and those concerning Thailand (Loichinger & Pothisiri, 2018; Zimmer & Amornsirisomboon, 2001). Although the prevalence of lower cognitive function is low relative to other ill-health prevalence, it was the cognitive health dimension that has the greatest gains when education differentials were adjusted in the estimation models.

Transmuting the prevalence of ill-health status and projected populations, health-adjusted dependency ratios reflecting each ill-health status individually had shown that there was an increase in dependency ratios among all three. Given those prior observation, it was observed that education gradient has the largest effect size on lower cognitive performance.

This chapter had questioned the notion of dependency of the older population. The traditional view that once a person reaches the ages of 60 years, then they gain disabilities and become dependent on society. This chronological perspective in ageing has been challenged in the literature (Bordone et al., 2014; Sanderson & Scherbov, 2008, 2015) as the population landscape has changed whereby life expectancies across many societies have increased and the well-being of people have also increased where fewer or later-onset disabilities are experienced. When health status and education attainment of individuals were considered in the present analysis for Thai society, it was observed that there were more in the older society who are free of ill-health status and are capable of further engaging society.

6.2.3. Characteristics approach to cognitive ageing

The main aim in chapter 5 was to estimate the speed of cognitive ageing depending on the human capital factors of education and income levels. To attain these estimates, the use of a novel method of analysis such as the characteristics approach was valuable such that it is an efficient means to display the gradients in cognition brought by education subgroups. The use of α-ages also reflects the situation of population structures where more people are living longer and that some

people may be performing better in terms of health. This method has been used on data from the U.S. and select European countries (Sanderson & Scherbov, 2010; Sanderson et al., 2016). These studies have been on physical health such as handgrip strength and chair rise speed only.

What this study had shown was that higher education and income levels have positive effects on the speed of cognitive ageing for older adults in Thailand. Although both human capital factors were found to associated with the development of cognitive ageing, the impact of education gradients was greater than income. Men who are aged about 70 years old with higher than primary level of education have the cognitive performance capacity as a male who is 60 years old and have lower than primary level of education. This advantage in cognitive performance was observed at varying degrees at different ages. Considering gender differentiation of cognitive decline, the benefit of higher than primary level of education was higher among women as observed here.

The findings in this portion of the thesis is supported in the literature indicating that education has a protective effect on the mind of individuals gained in younger ages and lasts to advanced ages (Stern, 2002; Zahodne et al., 2015). There was a gender differentiation in the effect of education which has been observed in the literature (Maurer, 2011). In terms of social dynamics, this effect on women is assumed in the theory of resource substitution whereas it is expressed that lacking in one resource is recompensed in another (Ross & Mirowsky, 2010). In the current context, as women have less resource with regard to income and societal power in the Thai situation, the effect of education is magnified.

6.3. Limitations of the research

As it had been mentioned throughout this thesis, studies on cognitive functioning in the context of Thai society have shortcomings and this has much impact on policy. Some countries had endeavoured on adapting cognitive status tests, like the MMSE and MoCA, to reflect the sociocultural underpinnings of their respective societies. This is important because the act of linguistically translating survey instruments may be insufficient and therefore produce an over- or underestimation of the prevalence of cognitive impairment. The lack of uniformity in the measure of cognitive performance was observed in this study such that it is a measure adapted from the literature and is not directly comparable to the results observed in other societies.

The way this issue is manifested in the present thesis is the choice of items to create an index of cognitive functioning. The number of words identified in the memory test in the PCWAS is fewer than those found in the HRS, SHARE, and SAGE. This is also true for the numeracy test. Although the index is valid and reliable as evident in the statistical tests performed, the comparability with other societies has to cautioned. For prospective surveys that would contain memory and numeracy tests again, the design would have to be able to accommodate what had already been done in the PCWAS if the prevalence trend is to be established. Having a reliable, valid, and comparable measure of cognitive health state in terms of between societies or between time periods would benefit Thai society in order to establish sound policies regarding cognitive healthcare.

Aside from the aforementioned general limitations, there are also specific points realised from each result chapter. Based on chapter 3 where the associated factors with cognitive performance was studied, the choice of covariates was limited by what is available in the dataset utilised. Other variables can be used for regression analyses including information on comorbidities or specific diagnosed health conditions (Porapakkham et al., 2008). Also, physical health tests like glucose and blood pressure can be incorporated in the analysis as these are alluded in the literature to have effect on cognitive health (Durazzo et al., 2010; McEwen & Gianaros, 2010a).

In chapter 4, income was excluded from the analysis involving future populations. The lack of population projection that account for income levels though does not diminish the value of analyses. As it had been done in the literature, education can be used as proxy for income as there is a particular level of correlation between the two human capital factors (Banks & Mazzonna, 2012; Sachs-Ericsson & Blazer, 2005). In chapter 5, the study on trajectories or speed of cognitive ageing by education and income utilised cross-sectional data on cognitive performance. A study using the characteristics approach on physical health measure as handgrip strength used longitudinal data (Sanderson et al., 2016).

6.4. Recommendations

Firstly, policy directions (6.4.1) concerning cognitive health of older persons are shown that may bear practical fruitions in order for Thailand to develop further its response to this population sub-group. After which, further research propositions are

shown for the continued development of the study of ageing in the context of a developing Asian country (6.4.2).

6.4.1. Policy implications

The main finding in this thesis was that education attainment bear variations in cognitive performance among older persons. Those with at least primary level of education, and even more so among those with higher than primary level, perform well with regard to cognition tasks. Gains in education could benefit those who are still in their younger years therefore ensuring that the student-age population gain as much schooling as this may have observable outcomes over the course of their lives. Socioeconomic gradients particularly on inequalities in education have to be addressed by ensuring the population attain better levels of education. Also, as it had been cautioned in the literature (Lutz et al., 2014), the progress and development of education is not only in terms of the number of years gained in attainment but also in its quality to make the learning of individuals integrative.

Formal schooling in younger years is not the only avenue to achieve the aim of education which is to generate personally and mentally empowered individuals. Current older populations can still attain the said benefit of learning through lifelong education (Lutz, 2019). Further learning of skills and gaining contemporary knowledge can offer mental stimulation which may have positive gains in cognitive abilities. Due to longer life expectancies of people with advanced ages, continuous learning can offer them further societal engagement through various activities as gainful employment or volunteer and other social activities.

6.4.2. Prospective research

The studies in this thesis contribute to the literature concerning education and cognitive function in later life. Many aspects of the studies can be further improved with respect to data. Firstly, the observations here are based on cross-sectional data therefore causal relations have not been established. It would be beneficial for future research endeavour to utilise national longitudinal surveys in order to trace peoples' change in health states among other factors that can be observed. As in chapter 3 of this thesis, causality was not established in the regression analyses. The factors presented offered association with improved cognitive performance among older persons. Although this is beneficial in itself, being able to track the cognitive decline of individuals with their respective personal attributes would advance studies in cognitive health of the older people in Thailand. Such a longitudinal perspective of cognitive decline would also be applicable to the characteristics approach in chapter 5. The decline in abilities can be disaggregated through the education and income levels of individuals and the estimates generated can be applied to population projections in order to create plans on healthcare needs.

Another aspect of analysis that can provide further understanding of cognitive ageing is the inclusion of items that are based on diagnostic measures are useful in the study of health dimensions. An example for cognitive function is the use of the MMSE which is an internationally accepted diagnostic tool for cognitive impairment. Although self-reported health measures are highly correlated with formal diagnostic measures, it is assiduous to use the latter for confirmation. This is demonstrable through the limitations of the results in chapter 4 on the current and projected

prevalence rates of ill health. There was no trend established in the analysis of ill health prevalence between the data points. The listed symptoms were absent or had changed in surveys over different surveys. Having uniform data which are based on symptoms and diagnostic data are beneficial especially if done in a longitudinal approach as the results would be more robust.

Appendices

Appendix 3.1: Measurement of demographic, socioeconomic, social engagement, and health behaviour and dimension covariates based on the 2016 PCWAS

Variable	Measurement
Age	Continuous
Residence	Categorical: 0 = Rural, 1 = Urban
Marital Status	Categorical: 0= Married, 1=Widowed, 2= Separated/ divorced/ never married
Education level	Categorical: 0 = Below primary, 1= Primary (4th to 6th grade), 2= Beyond primary
Employed in the past year	Dichotomous: 0= No, 1=Yes
Average annual income	Categorical: 0=Less than 30,000, 1= 30,000-59,999, 2= 60,000-99,999, 3= 100,000 and above
Perceived income adequacy	Dichotomous: 0= No, 1=Yes
Self-rated Health	Categorical: 0=Poor, 1=Good
Experienced physical limitation	Categorical: 0=None, 1=At least one
Experienced depressive symptoms	Categorical: 0=None, 1=At least one
Smoking cigarettes	Dichotomous: 0= No, 1=Yes
Drinking alcohol	Dichotomous: 0= No, 1=Yes
Positive health behaviour	Dichotomous: 0= No, 1=Yes
Living arrangement	Categorical: 0= Alone, 1= Spouse only, 2=Child only, 3=Spouse and children, 4=Others
Membership to at least one organisation	Dichotomous: 0= No, 1=Yes
Participated in community activities	Dichotomous: 0= No, 1=Yes
Participated in volunteering activities	Dichotomous: 0= No, 1=Yes
Religious engagement	Dichotomous: 0= No, 1=Yes

Appendix 3.2: OLS regression model coefficients of cognitive performance by gender, Thai persons aged at least 60 years

	Males	**Females**
Age	-0.040***	-0.044***
Residence (Rural=ref)	0.086	0.09
Marital Status (Married=ref)		
Widowed	-0.075	-0.019
Separated/divorced/never married	-0.022	-0.059
Education level (Below primary=ref)		
Primary level	0.637***	0.796***
Higher than primary level	0.952***	1.439***
Employed in the past year (No=ref)	-0.055	0.023
Average annual income (<30,000=ref)		
30,000–59,999	0.263**	0.261**
60,000–99,999	0.288**	0.163**
100,000 and above	0.321**	0.237**
Perceived income adequacy (No=ref)	0.226**	0.115
Self-rated health (Poor=ref)	0.061	0.061
Experienced 1+ physical limitation	-0.214**	-0.088
Experienced 1+ depressive symptoms	-0.051	-0.263***
Smoking cigarettes (No=ref)	-0.087	-0.032
Drinking alcohol (No=ref)	-0.024	-0.117
Positive healthful behaviour (No=ref)	0.218*	0.141
Living arrangement (Alone=ref)		
Spouse only	0.302	0.002
Child only	0.377**	0.026
Spouse and children	0.315*	0.029
Others	0.362*	0.032
Membership of at least one organisation	0.098	0.122
Participated in community activities	0.087	0.069
Participated in volunteering activities	0.051	0.086
Religious engagement	0.301**	0.121
Constant	7.740***	8.390***
R^2	0.162	0.171

*, ** and *** denote significant differences between older men and women for P≤0.10, P≤0.05 and P≤0.001, respectively.

Appendix 4.1: Percentage distribution of the older population by age groups according to education level; Thailand; 2011, 2014, and 2016

2011						
	60-64	**65-69**	**70-74**	**75-79**	**80+**	**Total**
Below primary education (n=4097)	18.11	19.94	20.46	18.43	23.05	100
Primary education (n=25626)	34.13	24.8	19.35	12.8	8.92	100
Above primary education (n=4450)	41.5	29.49	15.88	7.64	5.48	100
2014						
	60-64	**65-69**	**70-74**	**75-79**	**80+**	**Total**
Below primary education (n=5930)	22.86	18.51	18.59	16.16	23.88	100
Primary education (n=26493)	34.68	23.95	17.33	12.1	11.94	100
Above primary education (n=6272)	37.14	25.69	16.63	10.41	10.13	100
2016						
	60-64	**65-69**	**70-74**	**75-79**	**80+**	**Total**
Below primary education (n=858)	25.61	18.76	20.65	17.5	17.47	100
Primary education (n=4057)	36.16	26.25	19.52	10.5	7.57	100
Above primary education (n=1386)	39.59	29.15	18.62	8.52	4.13	100

Sources: 2011 and 2014 SOPT; 2016 PCWAS.

Appendix: OLS regression model coefficients of cognitive performance by gender, Thai persons aged at least 60 years		
	Males	**Females**

Age	-0.040***	-0.044***
Residence (Rural=ref)	0.086	0.09
Marital Status (Married=ref)		
Widowed	-0.075	-0.019
Separated/divorced/never married	-0.022	-0.059
Education level (Below primary=ref)		
Primary level	0.637***	0.796***
Higher than primary level	0.952***	1.439***
Employed in the past year (No=ref)	-0.055	0.023
Average annual income (<30,000=ref)		
30,000–59,999	0.263**	0.261**
60,000–99,999	0.288**	0.163**
100,000 and above	0.321**	0.237**
Perceived income adequacy (No=ref)	0.226**	0.115
Self-rated health (Poor=ref)	0.061	0.061

Experienced 1+ physical limitation	-0.214**	-0.088
Experienced 1+ depressive symptoms	-0.051	-0.263***
Smoking cigarettes (No=ref)	-0.087	-0.032
Drinking alcohol (No=ref)	-0.024	-0.117
Positive healthful behaviour (No=ref)	0.218*	0.141
Living arrangement (Alone=ref)		
Spouse only	0.302	0.002
Child only	0.377**	0.026
Spouse and children	0.315*	0.029
Others	0.362*	0.032
Membership of at least one organisation	0.098	0.122
Participated in community activities	0.087	0.069
Participated in volunteering activities	0.051	0.086
Religious engagement	0.301**	0.121
Constant	7.740***	8.390***

R2	0.162	0.171
*, ** and *** denote significant differences between older men and women for P≤0.10, P≤0.05 and P≤0.001, respectively.		

Appendix 4.2: Percentage of older persons with ill-health status by health dimension by age groups and education attainment among older gender, Thailand; 2016

Male		Lower cognitive performance	IADL	Depression symptoms
Below primary education (n=245)	**60-64**	25.58	20.93	32.61
	65-69	27.27	25.67	37.5
	70-74	47.92	39.58	43.94
	75-79	50.00	43.48	50.00
	80+	58.70	54.76	60.47
Primary education (n=1634)	**60-64**	17.35	9.38	29.20
	65-69	19.87	13.62	30.81
	70-74	22.08	22.73	33.71
	75-79	25.95	26.49	37.99
	80+	43.19	43.75	42.19
Above primary education (n=732)	**60-64**	5.28	5.28	22.54
	65-69	6.40	7.39	27.09
	70-74	14.19	12.26	31.61
	75-79	20.69	18.97	32.76
	80+	30.25	36.20	40.63
Female		**Lower cognitive performance**	**IADL**	**Depression symptoms**
Below primary education (n=613)	**60-64**	27.78	32.00	50.00
	65-69	41.60	38.10	51.2
	70-74	43.51	58.78	54.78
	75-79	47.83	66.09	55.17
	80+	61.21	80.17	55.73
Primary education (n=2423)	**60-64**	14.43	17.27	37.84
	65-69	19.84	30.41	39.71
	70-74	27.03	42.83	41.06
	75-79	33.46	58.56	43.90
	80+	40.76	70.11	44.57
Above primary education (n=654)	**60-64**	2.21	5.17	27.68
	65-69	7.53	18.28	30.11
	70-74	8.85	29.20	32.74
	75-79	13.73	43.14	33.33
	80+	30.30	63.64	42.42

Source: 2016 PCWAS.

REFERENCES

Aarsland, D., Kvaløy, J. T., Andersen, K., Larsen, J. P., Tang, M. X., Lolk, A., . . . Marder, K. (2007). The effect of age of onset of PD on risk of dementia. *Journal of Neurology, 254*(1), 38-45. doi:10.1007/s00415-006-0234-8

Aartsen, M. J., Smits, C. H. M., van Tilburg, T., Knipscheer, K. C. P. M., & Deeg, D. J. H. (2002). Activity in Older Adults: Cause or Consequence of Cognitive Functioning? A Longitudinal Study on Everyday Activities and Cognitive Performance in Older Adults. *The Journals of Gerontology Series B, 57*(2), P153-P162. doi:10.1093/geronb/57.2.P153

Adam, S., Bay, C., Bonsang, E., Germain, S., & Perelman, S. (2006) Occupational activities and cognitive reserve: A frontier approach applied to the Survey on Health, Ageing, and Retirement in Europe (SHARE). In, *CREPP Working Papers* (0605 ed.): HEC-Management School, University of Liège.

Adam, S., Bonsang, E., Grotz, C., & Perelman, S. (2013). Occupational activity and cognitive reserve: implications in terms of prevention of cognitive aging and Alzheimer's disease. *Clinical Interventions in Aging 8*, 377-390. doi:10.2147/CIA.S39921

Adler, N., Boyce, T., Chesney, M., Cohen, S., Folkman, S., Kahn, R., & Syme, S. L. (1994). Socioeconomic status and health: The challenge of the gradient. *American Psychologist, 49*(1), 15-24.

Allerhand, M., Gale, C. R., & Deary, I. J. (2014). The dynamic relationship between cognitive function and positive well-being in older people: A prospective study using the English Longitudinal Study of Aging. *Psychology and Aging, 29*(2), 306-318.

Anderson, N. D., & Craik, F. I. M. (2017). 50 years of cognitive aging theory. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 72*(1), 1-6. doi:10.1093/geronb/gbw108

Andrade, F. C. D., Corona, L. P., Lebrão, M. L., & Duarte, Y. A. d. O. (2014). Life expectancy with and without cognitive impairment among Brazilian older adults. *Archives of Gerontology and Geriatrics, 58*(2), 219-225.

Bajaj, J. S., Riggio, O., Allampati, S., Prakash, R., Gioia, S., Onori, E., . . . Mullen, K. D. (2013). Cognitive Dysfunction Is Associated With Poor Socioeconomic Status in Patients With Cirrhosis: An International Multicenter Study. *Clinical Gastroenterology and Hepatology, 11*(11), 1511-1516. doi:10.1016/j.cgh.2013.05.010

Baker, D. P., Smith, W. C., Muñoz, I. G., Jeon, H., Fu, T., Leon, J., . . . Horvatek, R. (2017). The Population Education Transition Curve: Education Gradients Across Population Exposure to New Health Risks. *Demography, 54*(5), 1873-1895. doi:10.1007/s13524-017-0608-9

Banks, J., & Mazzonna, F. (2012). The Effect of Education on Old Age Cognitive Abilities: Evidence from a Regression Discontinuity Design. *The Economic Journal, 122*(560), 418-448. doi:https://doi.org/10.1111/j.1468-0297.2012.02499.x

Barford, A., Dorling, D., Davey Smith, G., & Shaw, M. (2006). Life expectancy: women now on top everywhere. *BMJ, 332*(7545), 808-808. doi:10.1136/bmj.332.7545.808

Basu, R. (2013). Effects of education and income on cognitive functioning among Indians aged 50 years and older: evidence from the Study on Global Ageing and Adult Health (SAGE) Wave 1 (2007-2010). *WHO South-East Asia Journal of Public Health, 2*(3-4), 156-164. doi:10.4103/2224-3151.115828

Batljan, I., Lagergren, M., & Thorslund, M. (2009). Population ageing in Sweden: The effect of change in educational composition on the future number of older people suffering severe ill-health. *European Journal of Ageing, 6*(3), 201-211. doi:10.1007/s10433-009-0120-1

Beard, J. R., & Bloom, D. E. (2015). Towards a comprehensive public health response to population ageing. *Lancet, 385*(9968), 658-661. doi:10.1016/S0140-6736(14)61461-6

Beard, J. R., Officer, A., de Carvalho, I. A., Sadana, R., Pot, A. M., Michel, J.-P., . . . Chatterji, S. (2016). The World report on ageing and health: A policy framework for healthy ageing. *Lancet, 387*(10033), 2145-2154. doi:10.1016/S0140-6736(15)00516-4

Beckie, T. M. (2012). A Systematic Review of Allostatic Load, Health, and Health Disparities. *Biological Research For Nursing, 14*(4), 311-346. doi:10.1177/1099800412455688

Bilotta, C., Casè, A., Nicolini, P., Mauri, S., Castelli, M., & Vergani, C. (2010). Social vulnerability, mental health and correlates of frailty in older outpatients living alone in the community in Italy. *Aging & Mental Health, 14*(8), 1024-1036. doi:10.1080/13607863.2010.508772

Birren, J. E. (1965). Age Changes in Speed of Behavior: Its Central Nature and Physiological Correlates. In A. T. Welford & J. E. Birren (Eds.), (pp. 191-216). Springfield, IL: Charles C. Thomas.

Bloom, D. E., Börsch-Supan, A., McGee, P., & Seike, A. (2012). Population Ageing: Macro Challenges and Policy Responses. In J. R. Beard, S. Biggs, D. E. Bloom, L. P. Fried, P. Hogan, A. Kalache, & S. J. Olshansky (Eds.), (pp. 35-38). Geneva: World Economic Forum.

Bloom, D. E., Chatterji, S., Kowal, P., Lloyd-Sherlock, P., McKee, M., Rechel, B., . . . Smith, J. P. (2015). Macroeconomic implications of population ageing and selected policy responses. *Lancet, 385*(9968), 649-657. doi:10.1016/S0140-6736(14)61464-1

Bongaarts, J., & Zimmer, Z. (2002). Living arrangements of older adults in the developing world: An analysis of demographic and health survey household surveys. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 57*(3), S145-157.

Bordone, V., Scherbov, S., & Steiber, N. (2014). *Is population ageing decelerating in terms of cognition?* Retrieved from Vienna:

Bordone, V., Scherbov, S., & Steiber, N. (2015). Smarter every day: The deceleration of population ageing in terms of cognition. *Intelligence, 52*, 90-96. doi:10.1016/j.intell.2015.07.005

Bordone, V., & Weber, D. (2012). Number of children and cognitive abilities in later life. *Vienna Yearbook of Population Research, 10*, 95-126.

Boustani, M. (2013). Dementia screening in primary care: not too fast! *Journal of the American Geriatrics Society, 61*(7), 1205-1207. doi:10.1111/jgs.12319_2

Brookmeyer, R., Johnson, E., Ziegler-Graham, K., & Arrighi, H. M. (2007). Forecasting the Global Burden of Alzheimer's Disease. *Alzheimer's & Dementia, 3*(3), 186-191. doi:10.1016/j.jalz.2007.04.381.

Buffel, T., Phillipson, C., & Scharf, T. (2012). Ageing in urban environments: Developing 'age-friendly' cities. *Critical Social Policy, 32*(4), 597-617. doi:10.1177/0261018311430457

Burton, C. L., Strauss, E., Bunce, D., Hunter, M. A., & Hultsch, D. F. (2009). Functional Abilities in Older Adults with Mild Cognitive Impairment. *Gerontology, 55*(5), 570-581.

Butterworth, P., Rodgers, B., & Windsor, T. D. (2009). Financial hardship, socio-economic position and depression: Results from the PATH Through Life Survey. *Social Science & Medicine, 69*, 229-237. doi:10.1016/j.socscimed.2009.05.008

Cagney, K. A., & Lauderdale, D. S. (2002). Education, Wealth, and Cognitive Function in Later Life. *The Journals of Gerontology Series B, 57*(2), P163-P172. doi:10.1093/geronb/57.2.P163

Capurso, A., Panza, F., Solfrizzi, V., Torres, F., Capurso, C., Mastroianni, F., & Del Parigi, A. (2000). All'età declino cognitivo correlato: valutazione e strategia di prevenzione [Age-related cognitive decline: evaluation and prevention strategy]. *Recenti Progressi in Medicina, 91*(3), 127-134.

Cassarino, M., & Setti, A. (2015). Environment as 'Brain Training': A review of geographical and physical environmental influences on cognitive ageing. *Ageing Research Review, 23*, 167-182. doi:10.1016/j.arr.2015.06.003

Chan, A., Malhotra, C., Malhotra, R., & Østbye, T. (2011). Living arrangements, social networks and depressive symptoms among older men and women in Singapore. *International Journal of Geriatric Psychiatry, 26*(6), 630-639. doi:10.1002/gps.2574

Charernboon, T., & Lerthattasilp, T. (2016). Characteristic Profiles of Activities of Daily Living and Relationship with Cognitive Performance in Thai Elderly with Different Stages from Normal Cognition Function, Mild Cognitive Impairment to Dementia. *Clinical Gerontologist, 39*(4), 307-323. doi:10.1080/07317115.2016.1162893

Charnvit, K. (2000). *1932 Revolution in Siam*. Bangkok: The Foundation for the Promotion of Social Sciences and Humanities Textbook Project.

Chatterji, S., Byles, J., Cutler, D. M., Seeman, T., & Verdes, E. (2015). Health, functioning and disability in older adults - Present status and future implications. *Lancet, 385*(9967), 563-575. doi:10.1016/S0140-6736(14)61462-8

Chatterji, S., Kowal, P., Mathers, C., Naidoo, N., Verdes, E., Smith, J. P., & Suzman, R. (2008). The health of aging populations in China and India. *Health Affairs, 27*(4), 1052-1063. doi:10.1377/hlthaff.27.4.1052

Christensen, K., Thinggaard, M., Oksuzyan, A., Steenstrup, T., Andersen-Ranberg, K., Jeune, B., . . . Vaupel, J. W. (2013). Physical and cognitive functioning of people older than 90 years: A comparison of two Danish cohorts born 10 years apart. *The Lancet, 382*, 1507-1513. doi:10.1016/S0140-6736(13)60777-1

Coe, N. B., & Zamarro, G. (2010). Retirement effects on health in Europe. *Journal of Health Economics, 30*, 77-86. doi:10.1016/j.jhealeco.2010.11.002

College of Population Studies. (2018). *A Report on the 2016 Population Change and Well-being in the Context of Ageing Society*. Bangkok: Chulalongkorn University.

Craik, F. I. M., & Bialystok, E. (2006). Cognition through the lifespan: mechanisms of change. *Trends in Cognitive Science, 10*(3), 131-138.

Craik, F. I. M., & Jennings, J. M. (1992). Human memory. In F. I. M. Craik & T. A. Salthouse (Eds.), (pp. 51-110). Hillsdale, NJ: Lawrence Erlbaum.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11*, 671-684.

Crimmins, E., & Beltrán-Sánchez, H. (2010). Mortality and morbidity trends: Is there compression of morbidity? *Journal of Gerontology - Social Sciences, 66B*(1), 75-86. doi:10.1093/geronb/gbq088

Cutler, D. M., & Lleras-Muney, A. (2006) Education and Health: Evaluating Theories and Evidence. In, *NBER Working Paper Series* (12352 ed.).

Cutler, D. M., & Lleras-Muney, A. (2010). Understanding Differences in Health Behaviors by Education. *Journal of Health Economics, 29*(1), 1-28. doi:10.1016/j.jhealeco.2009.10.003

Cutler, D. M., & Lleras-Muney, A. (2012) Education and Health: Insights from International Comparisons. In, *NBER Working Paper* (17738 ed.). Cambridge, MA.

d'Esposito, M., & Postle, B. R. (2015). The cognitive neuroscience of working memory. *Annual Review of Psychology, 66*, 115-142. doi:10.1146/annurev-psych-010814-015031

d'Uva, T. B., O'Donnell, O., & Van Doorslaer, E. (2008). Differential health reporting by education level and its impact on the measurement of health inequalities among older Europeans. *International Journal of Epidemiology, 37*, 1375-1383. doi:10.1093/ije/dyn146

de Mello, M. T., Lemos, V. d. A., Antunes, H. K. M., Bittencourt, L., Santos-Silva, R., & Tufik, S. (2013). Relationship between physical activity and depression and anxiety symptoms: A population study. *Journal of Affective Disorders, 149*(1-3), 241-246. doi:10.1016/J.JAD.2013.01.035

Deary, I. J., & Johnson, W. (2010). Intelligence and education: causal perceptions drive analytic processes and therefore conclusions. *International Journal of Epidemiology, 39*, 1362-1369. doi:10.1093/ije/dyq072

Degenhardt, L., Whiteford, H., Hall, W., & Vos, T. (2009). Estimating the burden of disease attributable to illicit drug use and mental disorders: what is 'Global Burden of Disease 2005' and why does it matter? *Addiction, 104*(9), 1466-1471. doi:10.1111/j.1360-0443.2009.02715.x

Department of Health - Ministry of Public Health. (2018). 4 Smart. Retrieved from https://www.anamai.moph.go.th/ewt_news.php?nid=11832

Dodge, H. H., Kadowaki, T., Hayakawa, T., Yamakawa, M., Sekikawa, A., & Ueshima, H. (2005). Cognitive Impairment as a Strong Predictor of Incident Disability in Specific ADL-IADL Tasks Among Community-Dwelling Elders: The Azuchi Study. *The Gerontologist, 45*(2), 222-230. doi:10.1093/geront/45.2.222

Dong, Y., Kumar Sharma, V., Poon-Lap Chan, B., Venketasubramanian, N., Luen Teoh, H., Chee Seong Seet, R., . . . Chen, C. (2010). The Montreal Cognitive

Assessment (MoCA) is superior to the Mini-Mental State Examination (MMSE) for the detection of vascular cognitive impairment after acute stroke. *Journal of the Neurological Sciences, 299*, 15-18. doi:10.1016/j.jns.2010.08.051

Durant, J., Leger, G. C., Banks, S. J., & Miller, J. B. (2016). Relationship between the Activities of Daily Living Questionnaire and the Montreal Cognitive Assessment. *Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring, 4*, 43-46. doi:10.1016/j.dadm.2016.06.001

Durazzo, T. C., Meyerhoff, D. J., & Nixon, S. J. (2010). Chronic cigarette smoking: Implications for neurocognition and brain neurobiology. *International Journal of Environmental Research and Public Health, 7*(10), 3760-3790. doi:10.3390/ijerph7103760

Evans, D. A., Hebert, L. E., Beckett, L. A., Scherr, P. A., Albert, M. S., Chown, M. J., . . . Taylor, J. O. (1997). Education and Other Measures of Socioeconomic Status and Risk of Incident Alzheimer Disease in a Defined Population of Older Persons. *Archives of Neurology, 54*(11), 1399-1405. doi:10.1001/archneur.1997.00550230066019

Ezeh, A. C., Bongaarts, J., & Mberu, B. (2012). Global population trends and policy options. *The Lancet, 380*(9837), 142-148. doi:10.1016/S0140-6736(12)60696-5

Feng, L., Ng, X.-T., Yap, P., Li, J., Lee, T.-S., Håkansson, K., . . . Ng, T.-P. (2014). Marital Status and Cognitive Impairment among Community-Dwelling Chinese Older Adults: The Role of Gender and Social Engagement. *Dementia and Geriatric Cognitive Disorders Extra, 4*(3), 375-384. doi:10.1159/000358584

Feng, L., Nyunt, M. S. Z., Gao, Q., Feng, L., Lee, T. S., Tsoi, T., . . . Ng, T. P. (2017). Physical frailty, cognitive impairment, and the risk of neurocognitive disorder in the Singapore Longitudinal Ageing Studies. *J Gerontol A Biol Sci Med Sci, 72*(3), 369-375. doi:10.1093/gerona/glw050

Ferrer, I. (2012). Defining Alzheimer as a common age-related neurodegenerative process not inevitably leading to dementia. *Progrerss in Neurobiology, 97*(1), 38-51. doi:10.1016/j.pneurobio.2012.03.005

Fiocco, A. J., & Yaffe, K. (2010). Defining successful aging: The importance of including cognitive function over time. *Archives of Neurology, 67*(7), 876-880.

Fleming, K., Kim, S. H., Doo, M., Maguire, G., & Potkin, S. G. (2003). Memory for emotional stimuli in patients with Alzheimer's disease. *American Journal of Alzheimer's Disease and other Dementias, 18*(6), 340-342.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*(3), 189-198.

Fry, G. W., & Bi, H. (2013). The evolution of educational reform in Thailand: The Thai educational paradox. *Journal of Educational Administration, 51*(3), 290-319. doi:10.1108/09578231311311483

Godefroy, O., Fickl, A., Roussel, M., Auribault, C., Jean, Bugnicourt, M., . . . Petitnicolas, G. (2011). Is the Montreal Cognitive Assessment superior to the Mini-Mental State Examination to detect poststroke cognitive impairment? A study with neuropsychological evaluation. *Stroke, 42*, 1712-1716. doi:10.1161/STROKEAHA.110.606277

Goh, J. O., & Park, D. C. (2009). Neuroplasticity and cognitive aging: The scaffolding theory of aging and cognition. *Restorative Neurology and Neuroscience, 27*(5), 391-403. doi:10.3233/RNN-2009-0493

Gold, D. A. (2012). An examination of instrumental activities of daily living assessment in older adults and mild cognitive impairment. *Journal of Clinical and Experimental Neuropsychology, 34*(1), 11-34. doi:10.1080/13803395.2011.614598

Grady, C. L., & Craik, F. I. M. (2000). Changes in memory processing with age. *Current Opinion in Neurobiology, 10*(2), 224-231.

Gray, M. (2006). *The role of advanced practice nurses in the care of people with chronic conditions*. Bangkok.

Hagger-Johnson, G., Sabia, S., Brunner, E. J., Shipley, M., Bobak, M., Marmot, M., . . . Singh-Manoux, A. (2013). Combined impact of smoking and heavy alcohol use on cognitive decline in early old age: Whitehall II prospective cohort study. *British Journal of Psychiatry, 203*(2), 120-125. doi:10.1192/bjp.bp.112.122960

Håkansson, K., Rovio, S., Helkala, E. L., Vilska, A. R., Winblad, B., Soininen, H., . . . Kivipelto, M. (2009). Association between mid-life marital status and cognitive function in later life: Population based cohort study. *BMJ (Online), 339*(7712), 99-99. doi:10.1136/bmj.b2462

Han, J. W., So, Y., Kim, T. H., Lee, D. Y., Ryu, S.-H., Kim, S. Y., . . . Woong Kim, K. (2017). Prevalence rates of dementia and mild cognitive impairment are affected by the diagnostic parameter changes for neurocognitive disorders in the DSM-5 in a Korean population. *Dementia and Geriatric Cognitive Disorders, 43*, 193-203. doi:10.1159/000458408

Hankinson, A. L., Daviglus, M. L., Bouchard, C., Carnethon, M., Lewis, C. E., Schreiner, P. J., . . . Sidney, S. (2010). Maintaining a high physical activity level over 20 years and weight gain. *Journal of the American Medical Association, 304*(23). doi:10.1001/jama.2010.1843

Hauser, R. M., & Weir, D. (2011). Longitudinal studies of aging in the United States. *EURAMERICA, 41*(1), 87-179.

Hayat, M. J., & Higgins, M. (2014). Understanding Poisson Regression. *Journal of Nursing Education, 53*(4), 207-215.

Hedden, T., & Gabrieli, J. D. (2004). Insights into the ageing mind: A view from cognitive neuroscience. *Nature Reviews. Neuroscience, 5*(2), 87-96. doi:10.1038/nrn1323

Heijdra, B. J., & Romp, W. E. (2009). Retirement, pensions, and ageing. *Journal of Public Economics, 93*(3-4), 586-604. doi:10.1016/j.jpubeco.2008.10.009

Herd, P., Goesling, B., & House, J. S. (2007). *Socioeconomic Position and Health: The Differential Effects of Education versus Income on the Onset versus Progression of Health Problems*. Retrieved from

Hill, T., Meunier, N., Polito, A., Seamans, K. M., Hill, T. R., Scully, L., . . . Cashman, K. D. (2010). Vitamin D status and measures of cognitive function in healthy older European adults. *European Journal of Clinical Nutrition, 64*, 1172-1178. doi:10.1038/ejcn.2010.117

Hinton, P. R., McMurray, I., & Brownlow, C. (2014). *SPSS Explained* (2nd ed.). London: Routledge.

Hodges, J. R., & Larner, A. J. (2017). Addenbrooke's Cognitive Examinations: ACE, ACE-R, ACE-III, ACEapp, and M-ACE. In A. J. Larner (Ed.), (pp. 109-137). Cham: Springer International Publishing.

Huisman, M., Kunst, A. E., & Mackenbach, J. P. (2003). Socioeconomic inequalities in morbidity among the elderly; A European overview. *Social Science and Medicine, 57*(5), 861-873. doi:10.1016/S0277-9536(02)00454-9

Ichimura, H., Shimizutani, S., & Hashimoto, H. (2009) JSTAR First Results 2009 Report. In T. a. I. Research Institute of Economy (Series Ed.), *IRETE Discussion Paper Series* (09047 ed.).

Jagger, C., Gillies, C., Moscone, F., Cambois, E., Van Oyen, H., Nusselder, W., . . . team, E. (2008). Inequalities in healthy life years in the 25 countries of the European Union in 2005: a cross-national meta-regression analysis. *The Lancet, 372*(9656), 2124-2131. doi:10.1016/S0140-6736(08)61594-9

James, B. D., Wilson, R. S., Barnes, L. L., & Bennett, D. A. (2011). Late-Life Social Activity and Cognitive Decline in Old Age. *Journal of the International Neuropsychological Society, 17*(6), 998-1005. doi:10.1017/S1355617711000531

Jeon, G.-S., Jang, S.-N., Rhee, S.-J., Kawachi, I., & Cho, S.-I. (2007). Gender Differences in Correlates of Mental Health among Elderly Koreans. *The Journals of Gerontology: Series B, 62*(5), S323-S329. doi:https://doi.org/10.1093/geronb/62.5.S323

Jeste, D. V., Depp, C. A., & Vahia, I. V. (2010). Successful cognitive and emotional aging. In (Vol. 9, pp. 78-84): Blackwell Publishing Ltd.

Jitapunkul, S., & Wivatvanit, S. (2009). National policies and programs for the aging population in Thailand. *Ageing International, 33*, 62-74. doi:10.1007/s12126-009-9027-6

Karp, A., Kåreholt, I., Qiu, C., Bellander, T., Winblad, B., & Fratiglioni, L. (2004). Relation of Education and Occupation-based Socioeconomic Status to Incident Alzheimer's Disease. *American Journal of Epidemiology, 159*(2), 175-183. doi:10.1093/aje/kwh018

KC, S., & Lentzner, H. (2010). The effect of education on adult mortality and disability: A global perspective. *Vienna Yearbook of Population Research, 8*, 201-235.

KC, S., Potančoková, M., Bauer, R., Goujon, A., & Striessnig, E. (2013). *Summary of Data, Assumptions and Methods for new Wittgenstein Centre for Demography and Global Human Capital (WIC) Population Projections by Age, Sex and Level of Education for 195 Countries to 2100 (Interim Report No. IR-12-018)*. Retrieved from Laxenburg, Austria: http://pure.iiasa.ac.at/id/eprint/10742/1/IR-13-018.pdf

Kim, K. W., Park, J. H., Kim, M.-H., Doo Kim, M., Kim, B.-J., Kim, S.-K., . . . Je Cho, M. (2011). A nationwide survey on the prevalence of dementia and mild cognitive impairment in South Korea. *Journal of Alzheimer's Disease, 23*, 281-291. doi:10.3233/JAD-2010-101221

Kleinman, A., Estrin, G. L., Usmani, S., Chisholm, D., Marquez, P. V., Evans, T. G., & Saxena, S. (2016). Time for mental health to come out of the shadows. *The Lancet, 387*(10035), 2274-2275. doi:10.1016/S0140-6736(16)30655-9

Knodel, J. (2014). The situation of older persons in Myanmar—an overview. *BOLD, 24*(3), 9-16.

Knodel, J., & Chayovan, N. (2008) Population ageing and the well-being of older persons in Thailand: Past trends, current situation and future challenges. In, *Papers in Population Ageing* (5 ed.). Bangkok.

Knodel, J., & Pothisiri, W. (2015). Intergenerational Living Arrangements in Myanmar and Thailand: A Comparative Analysis. *Journal of Cross Cultural Gerontology, 30*, 1-20.

Knodel, J., Prachuabmoh, V., & Chayovan, N. (2013). *The Changing Well-being of Thai Elderly: An Update from the 2011 Survey of Older Persons in Thailand*. Chiang Mai: HelpAge International.

Knodel, J., Teerawichitchainan, B., & Pothisiri, W. (2018). Caring for Thai Older Persons With Long-Term Care Needs. *Journal of Aging and Health, 30*(10), 1516-1535. doi:10.1177/0898264318798205

Knodel, J., Teerawichitchainan, B., Prachuabmoh, V., & Pothisiri, W. (2015). *The situation of Thailand's older population: An update based on the 2014 survey of older persons in Thailand*. Retrieved from Chiang Mai:

Kochhann, R., Santos Varela, J., Saraiva, C., Lisboa, M., Lorena, M., & Chaves, F. (2010). The Mini Mental State Examination Review of cutoff points adjusted for schooling in a large Southern Brazilian sample. *Dementia & Neuropsychologia, 4*(1), 35-41.

Köhler, S., van Boxtel, M. P. J., van Os, J., Thomas, A. J., O'Brien, J. T., Jolles, J., . . . Allardyce, J. (2010). Depressive Symptoms and Cognitive Decline in Community-Dwelling Older Adults. *Journal of the American Geriatrics Society, 58*(5), 873-879. doi:10.1111/j.1532-5415.2010.02807.x

Kokmen, E., Naessens, J. M., & Offord, K. P. (1987). *A Short Test of Mental Status: Description and Preliminary Results*. Retrieved from https://www.mayoclinicproceedings.org/article/S0025-6196(12)61905-3/pdf

Krueger, K. R., Wilson, R. S., Kamenetsky, J. M., Barnes, L. L., Bienias, J. L., & Bennett, D. A. (2009). Social engagement and cognitive function in old age. *Experimental Aging Research, 35*(1), 45-60. doi:10.1080/03610730802545028

Lafortune, G., & Balestat, G. (2007) Trends in Severe Disability Among Elderly People: Assessing the Evidence in 12 OECD Countries and the Future Implications. In, *OECD Health Working Papers* (26 ed.).

Langa, K. M., Llewellyn, D. J., Lang, I. A., Weir, D. R., Wallace, R. B., Kabeto, M. U., & Huppert, F. A. (2009). Cognitive health among older adults in the United States and in England. *BMC Geriatrics, 9*. doi:10.1186/1471-2318-9-23

Lebreton, M., Barnes, A., Miettunen, J., Peltonen, L., Ridler, K., Veijola, J., . . . Murray, G. K. (2009). The brain structural disposition to social interaction. *European Journal of Neuroscience, 29*(11), 2247-2252. doi:10.1111/j.1460-9568.2009.06782.x

Lee, J. Y., Lee, D. W., Cho, S. J., Na, D. L., Jeon, H. J., Kim, S.-K., . . . Cho, M. J. (2008). Brief screening for Mild Cognitive Impairment in elderly outpatient clinic: Validation of the Korean version of the Montreal Cognitive Assessment. *Journal of Geriatric Psychiatry and Neurology, 21*(2), 104-110. doi:10.1177/0891988708316855

Lee, L., Kang, S. A., Lee, H. O., Lee, B. H., Park, J. S., Kim, J. H., . . . Lee, J. E. (2001). Relationships between dietary intake and cognitive function level in Korean elderly people. *Public Health, 115*, 133-138.

Lee, Y., Back, J. H., Kim, J., Kim, S.-H., Na, D. L., Cheong, H.-K., . . . Kim, Y. G. (2010). Systematic review of health behavioral risks and cognitive health in older adults. *International Psychogeriatrics, 22*(2), 174-187. doi:10.1017/S1041610209991189

Lee, Y., & Shinkai, S. (2005). Correlates of cognitive impairment and depressive symptoms among older adults in Korea and Japan. *International Journal of Geriatric Psychiatry, 20*, 576-586. doi:10.1002/gps.1313

Lin, K. A., Choudhury, K. R., Rathakrishnan, B. G., Marks, D. M., Petrella, J. R., & Doraiswamy, P. M. (2015). Marked gender differences in progression of mild cognitive impairment over 8 years. *Alzheimer's & Dementia: Translational Research & Clinical Interventions, 1*(2), 103-110. doi:10.1016/j.trci.2015.07.001

Litwin, H. (2009). Social Networks and Well-being: A Comparison of Older People in Mediterranean and Non-Mediterranean Countries. *The Journals of Gerontology Series B, 65B*(5), 599-608. doi:https://doi.org/10.1093/geronb/gbp104

Loichinger, E., & Pothisiri, W. (2018). Health prospects of older persons in Thailand: the role of education. *Asian Population Studies, 14*(3), 310-329. doi:10.1080/17441730.2018.1532140

Lutz, W. (2009). Editorial: Towards a world of 2-6 billion well-educated and therefore healthy and wealthy people. *Journal of the Royal Society: Series A, 172*, 701-705.

Lutz, W. (2010). Education will be at the heart of 21st century demography. *Vienna Yearbook of Population Research, 8*(9-16).

Lutz, W. (2019). *Brain Power for Sustainable Development: The Cognitive Preconditions for a Succussful Sustainability Transition*. Berlin: German National Academy of Sciences Leopoldina.

Lutz, W., Butz, W. P., & KC, S. (2014). *World population and human capital in the twenty-first century*: Oxford University Press.

Lutz, W., Goujon, A., KC, S., Stonawski, M., & Stilianakis, N. (2018). *Demographic and Human Capital Scenarios for the 21st Century: 2018 assessment for 201 countries*: Publications Office of the European Union.

Lutz, W., Goujon, A., & Wils, A. (2008). The Population Dynamics of Human Capital Accumulation. *Population and Development Review, 34*(149-187).

Ma, W. J., Husain, M., & Bays, P. M. (2014). Changing concepts of working memory. *Nature Neuroscience, 17*(3), 347-356. doi:10.1038/nn.3655

Manton, K. G., Gu, X., & Lamb, V. L. (2006). Long-Term Trends in Life Expectancy and Active Life Expectancy in the United States. *Population and Development Review, 32*(1), 81-105. doi:10.1111/j.1728-4457.2006.00106.x

Maurer, J. (2011). Education and Male-Female Differences in Later-Life Cognition: International Evidence From Latin America and the Caribbean. *Demography, 48*, 915-930. doi:10.1007/s13524-011-0048-x

May, C. P., Hasher, L., & Kane, M. J. (1999). The role of interference in memory span. *Memory & Cognition, 27*, 759-767.

Mazzuco, S., Meggiolaro, S., Ongaro, F., & Toffolutti, V. (2017). Living arrangement and cognitive decline among older people in Europe. *Ageing and Society 37*, 1111-1133. doi:10.1017/S0144686X16000374

McEwen, B. S., & Gianaros, P. J. (2010a). Central role of the brain in stress and adaptation: Links to socioeconomic status, health, and disease. *Annals of the*

New York Academy of Sciences, 1186(1), 190-222. doi:10.1111/j.1749-6632.2009.05331.x

McEwen, B. S., & Gianaros, P. J. (2010b). Stress- and Allostasis-Induced Brain Plasticity. *Annual Review of Medicine, 62*, 431-445. doi:https://doi.org/10.1146/annurev-med-052209-100430

McGue, M., & Christensen, K. (2001). The heritability of cognitive functioning in very old adults: evidence from Danish twins aged 70 years and older. *Psychology and Aging, 28*(2), 272-280. doi:10.1037//0882-7974.16.2.272

McGue, M., & Christensen, K. (2002). The heritability of cognitive functioning in very old adults: evidence from Danish twins aged 70 years and older. *Experimental Aging Research, 28*(4), 435-451. doi:10.1080/03610730290080416org/10.1080/03610730290080416

Meng, X., & d'Arcy, C. (2012). Education and Dementia in the Context of the Cognitive Reserve Hypothesis: A Systematic Review with Meta-Analyses and Qualitative Analyses. *PLoS ONE 7*(6), e38268-e38268. doi:10.1371/journal.pone.0038268

Mielke, M. M., Vemuri, P., & Rocca, W. A. (2014). Clinical epidemiology of Alzheimer's disease: Assessing sex and gender differences. *Clinical epidemiology, 6*, 37-48. doi:10.2147/CLEP.S37929

Millán-Calenti, J. C., Tubío, J., Pita-Fernández, S., González-Abraldes, I., Lorenzo, T., Fernández-Arruty, T., & Maseda, A. (2010). Prevalence of functional disability in activities of daily living (ADL), instrumental activities of daily living (IADL) and associated factors, as predictors of morbidity and mortality. *Archives of Gerontology and Geriatrics, 50*(3), 306-310. doi:10.1016/j.archger.2009.04.017

Muszyńska, M. M., & Rau, R. (2012). The old-age healthy dependency ratio in Europe. *Population Ageing, 5*, 151-162.

Naing, N. N. (2000). Easy way to learn standardization : direct and indirect methods. *The Malaysian Journal of Medical Sciences : MJMS, 7*(1), 10-15.

Nasreddine, Z. S., Phillips, N. A., Bedirian, V., Cafbonneau, S., Whitehead, V., Collin, I., . . . Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society, 53*(4), 695-699.

National Statistics Office. (2012). *A Report on the 2011 Survey of Older Persons in Thailand (in Thai)*. Bangkok: National Statistics Office.

National Statistics Office. (2014). *The 2014 Survey of the Older Persons in Thailand*. Retrieved from Bangkok:

National Statistics Office. (2018). *Report on the 2017 Survey of the Older Persons in Thailand*: Ministry of Digital Economy and Society.

Natthapoj, V. T. (2011). Thailand: educational equality and quality. In C. Brock & L. P. Symaco (Eds.), (pp. 197-219). Oxford: Symposium Books.

Nelson, K. (1996). *Language in Cognitive Development: Emergence of the Mediated Mind*: Cambridge University Press.

Nitungkorn, S. (1988). The Problems of Secondary Education Expansion in Thailand. *Southeast Asian Studies, 26*(1), 24-41.

Noble, K. G., Norman, M. F., & Farah, M. J. (2005). Neurocognitive correlates of socioeconomic status in kindergarten children. *Developmental Science, 8*(1), 74-87.

Office of the National Education, C. (2002). *National Education Act 1999*: ONEC.

Oh, D. H., Park, J. H., Lee, H. Y., Kim, S. A. K., Choi, B. Y., & Nam, J. H. (2015). Association between living arrangements and depressive symptoms among older women and men in South Korea. *Social Psychiatry and Psychiatric Epidemiology, 50*, 133-141. doi:10.1007/s00127-014-0904-2

Oksuzyan, A., Crimmins, E., Saito, Y., O'Rand, A., Vaupel, J. W., & Christensen, K. (2010). Cross-national comparison of sex differences in health and mortality in Denmark, Japan and the US. *European Journal of Epidemiology, 25*(7), 471-480. doi:10.1007/s10654-010-9460-6

Pacharapimon, S., & Gamage, D. T. (2010). Thailand: the development of education system since 1220. In Y. Zhao (Ed.), (pp. 425-441). New York, NY: Routledge.

Park, D. C., & Festini, S. B. (2017). Theories of Memory and Aging: A Look at the Past and a Glimpse of the Future. *he Journals of Gerontology. Series B, Psychological Sciences and Social Sciences, 72*(1), 82-90. doi:10.1093/geronb/gbw066

Paú, C., Ribeiro, O., & Santos, P. (2010). Cognitive impairment in old people living in the community. *Archives of Gerontology and Geriatrics, 51*, 121-124. doi:10.1016/j.archger.2009.09.037

Pendlebury, S. T., Cuthbertson, F. C., Welch, S. J. V., Mehta, Z., & Rothwell, P. M. (2010). Underestimation of cognitive impairment by Mini-Mental State Examination versus the Montreal Cognitive Assessment in patients with transient ischemic attack and stroke: a population-based study. *Stroke, 41*, 1290-1293. doi:10.1161/STROKEAHA.110.579888

Pendlebury, S. T., Mariz, J., Bull, L., Mehta, Z., & Rothwell, P. M. (2012). MoCA, ACE-R and MMSE versus the NINDS-CSN VCI Harmonisation Standards Neuropsychological Battery after TIA and stroke. *Stroke, 43*(2), 464-469. doi:10.1161/STROKEAHA.111.633586

Petersen, R. C., Roberts, R. O., Knopman, D. S., Geda, Y. E., Cha, R. H., Pankratz, V. S., . . . Rocca, W. A. (2010). Prevalence of mild cognitive impairment is higher in men: The Mayo Clinic Study of Aging. *Neurology, 75*(10), 889-897. doi:10.1212/WNL.0b013e3181f11d85

Phrommintikul, A., Sa-Nguanmoo, P., Sripetchwandee, J., Vathesatogkit, P., Chattipakorn, N., & Chattipakorn, S. C. (2018). Factors associated with cognitive impairment in elderly versus nonelderly patients with metabolic syndrome: the different roles of FGF21 OPEN. *Scientific Reports, 8*, 5174-5174. doi:10.1038/s41598-018-23550-9

Piha, K., Laaksonen, M., Martikainen, P., Rahkonen, O., & Lahelma, E. (2010). Interrelationships between education, occupational class, income and sickness absence. *The European Journal of Public Health, 20*(3), 276-280. doi:10.1093/eurpub/ckp162

Porapakkham, Y., Pattaraarchai, J., & Aekplakorn, W. (2008). Prevalence, awareness, treatment and control of hypertension and diabetes mellitus among the elderly: the 2004 National Health Examination Survey Ill, Thailand. *Singapore Medical Journal, 49*(11), 868-873.

Prince, M., Patel, V., Saxena, S., Maj, M., Maselko, J., Phillips, M. R., & Rahman, A. (2007). No health without mental health. *Lancet, 370*(9590), 859-877. doi:10.1016/S0140-6736(07)61238-0

Quashie, N. T., & Pothisiri, W. (2019). Rural-urban gaps in health care utilization among older Thais: The role of family support. *Archives of Gerontology and Geriatrics, 81*, 201-208. doi:10.1016/j.archger.2018.12.011

Ravaglia, G., Forti, P., Montesi, F., Lucicesare, A., Pisacane, N., Rietti, E., . . . Mecocci, P. (2008). Mild Cognitive Impairment: Epidemiology and dementia risk in an elderly Italian population. *Journal of the American Geriatrics Society, 56*, 51-58. doi:10.1111/j.1532-5415.2007.01503.x

Reiner, M., Niermann, C., Jekauc, D., & Woll, A. (2013). Long-term health benefits of physical activity - A systematic review of longitudinal studies. *BMC Public Health, 13*. doi:10.1186/1471-2458-13-813

Reppermund, S., Brodaty, H., Crawford, J. D., Kochan, N. A., Draper, B., Slavin, M. J., . . . Sachdev, P. S. (2013). Impairment in instrumental activities of daily living with high cognitive demand is an early marker of mild cognitive impairment: the Sydney Memory and Ageing Study. *Psychological Medicine, 43*(11), 2437-2445. doi:10.1017/S003329171200308X

Reuter-Lorenz, P. A., & Park, D. C. (2014). How does it STAC up? Revisiting the scaffolding theory of aging and cognition. *Neuropsychology Review, 24*(3), 355-370. doi:10.1007/s11065-014-9270-9

Richards, M., & Sacker, A. (2011). Is education causal? Yes. *International Journal of Epidemiology, 40*(2), 516-518. doi:10.1093/ije/dyq166

Rieker, P. P., & Bird, C. E. (2005). Rethinking gender differences in health: why we need to integrate social and biological perspectives. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences, 60 Spec No*, 40-47.

Roalf, D. R., Moberg, P. J., Xie, S. X., Wolk, D. A., Moelter, S. T., & Arnold, S. E. (2013). Comparative accuracies of two common screening instruments for classification of Alzheimer's disease, mild cognitive impairment, and healthy aging. *Alzheimer's & Dementia, 9*, 529-537. doi:10.1016/j.jalz.2012.10.001

Roalf, D. R., Moore, T. M., Mechanic-Hamilton, D., Wolk, D. A., Arnold, S. E., Weintraub, D. A., & Moberg, P. J. (2017). Bridging cognitive screening tests in neurologic disorders: A crosswalk between the short Montreal Cognitive Assessment and Mini-Mental State Examination. *Alzheimer's & Dementia, 13*, 947-952. doi:10.1016/j.jalz.2017.01.015

Rodakowski, J., Skidmore, E. R., Reynolds, C. F., Dew, M. A., Butters, M. A., Holm, M. B., . . . Rogers, J. C. (2014). Can Performance on Daily Activities Discriminate Between Older Adults with Normal Cognitive Function and Those with Mild Cognitive Impairment? *Journal of the American Geriatrics Society, 62*(7), 1347-1352. doi:10.1111/jgs.12878

Rodríguez-Sánchez, E., Mora-Simón, S., Patino-Alonso, M. C., García-García, R., Escribano-Hernández, A., García-Ortiz, L., . . . Gómez-Marcos, M. A. (2011). Prevalence of cognitive impairment in individuals aged over 65 in an urban area: DERIVA study. *BMC Neurology, 11*(1), 1-13. doi:10.1186/1471-2377-11-147

Ross, C. E., & Mirowsky, J. (1999). Refining the association between education and health: the effects of quantity, credential, and selectivity. *Demography, 36*, 445-460.

Ross, C. E., & Mirowsky, J. (2010). Gender and the health benefits of education. *Sociological Quarterly, 51*(1), 1-19. doi:10.1111/j.1533-8525.2009.01164.x

Sachs-Ericsson, N., & Blazer, D. G. (2005). Racial Differences in Cognitive Decline in a Sample of Community-Dwelling Older Adults: The Mediating Role of Education and Literacy. *The American Journal of Geriatric Psychiatry, 13*(11), 968-975. doi:https://doi.org/10.1097/00019442-200511000-00007

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review, 103*(3), 403-428.

Sanderson, W. C., & Scherbov, S. (2005). Average remaining lifetimes can increase as human populations age. *Nature, 435*(7043), 811-813. doi:10.1038/nature03593

Sanderson, W. C., & Scherbov, S. (2007). A new perspective on population aging. *Demographic Research, 16*, 27-58. doi:10.4054/DemRes.2007.16.2

Sanderson, W. C., & Scherbov, S. (2008). Rethinking Age and Aging. *Population Bulletin, 63*(4).

Sanderson, W. C., & Scherbov, S. (2010). Remeasuring aging. *Science, 329*(5997), 1287-1288.

Sanderson, W. C., & Scherbov, S. (2013). The characteristics approach to the measurement of population aging. *Population and Development Review, 39*(4), 673-685.

Sanderson, W. C., & Scherbov, S. (2014). Measuring the Speed of Aging across Population Subgroups. *PLOS ONE, 9*(5), e96289-e96289. doi:10.1371/journal.pone.0096289

Sanderson, W. C., & Scherbov, S. (2015). Are We Overly Dependent on Conventional Dependency Ratios? *Population and Development Review, 41*(4), 687-708. doi:doi:10.1111/j.1728-4457.2015.00091.x

Sanderson, W. C., & Scherbov, S. (2016). A unifying framework for the study of population aging. *Vienna Yearbook of Population Research, 14*, 7-39. doi:10.1553/populationyearbook2016s007

Sanderson, W. C., Scherbov, S., Lutz, W., & O'Neil, B. C. (2004). Applications of Probabilistic Population Forecasting. In W. Lutz, W. C. Sanderson, & S. Scherbov (Eds.), *The End of World Population Growth in the 21 st Century: New Challenges for Human Capital Formation and Sustainable Development*. London: Earthscan.

Sanderson, W. C., Scherbov, S., Weber, D., & Bordone, V. (2016). Combined Measures of Upper and Lower Body Strength and Subgroup Differences in Subsequent Survival Among the Older Population of England. *Journal of Aging and Health, 28*(7), 1178-1193. doi:10.1177/0898264316656515

Sattler, C., Toro, P., Schönknecht, P., & Schröder, J. (2012). Cognitive activity, education and socioeconomic status as preventive factors for mild cognitive impairment and Alzheimer's disease. *Psychiatry Research, 196*(1), 90-95. doi:10.1016/J.PSYCHRES.2011.11.012

Scherbov, S., & Sanderson, W. C. (2016). New Approaches to the Conceptualization and Measurement of Age and Aging. *Journal of Aging and Health, 28*(7), 1159-1177. doi:10.1177/0898264316656517

Schiller, J. S., Lucas, J. W., & Peregoy, J. A. (2012) Summary health statistics for U.S. adults : National Health Interview Survey, 2011. In, *Vital Health Stat Vol. 10* (256 ed.): National Center for Health Statistics.

Schnittker, J. (2004). Education and the changing shape of the income gradient in health. *Journal of Health and Social Behavior, 45*(3), 286-305. doi:10.1177/002214650404500304

Schöllgen, I., Huxhold, O., & Tesch-Römer, C. (2010). Socioeconomic status and health in the second half of life: findings from the German Ageing Survey. *European Journal of Ageing, 7*, 17-28. doi:10.1007/s10433-010-0140-x

Seinfeld, S., Figueroa, H., Ortiz-Gil, J., & Sanchez-Vives, M. V. (2013). Effects of music learning and piano practice on cognitive function, mood and quality of life in older adults. *Frontiers in Psychology, 4*. doi:10.3389/fpsyg.2013.00810

Senanarong, V., Assavisaraporn, S., Sivasiriyanonds, N., Printarakul, T., Jamjumrus, P., Udompunthuruk, S., & Poungvarin, N. (2001). The IQCODE: an alternative screening test for dementia for low educated Thai elderly. *Journal of the Medical Association of Thailand, 84*(5), 648-655.

Shimada, H., Makizako, H., Doi, T., Phd, Y., Lee Phd, S., Park Phd, H., & Suzuki, T. (2013). Combined prevalence of frailty and mild cognitive impairment in a population of elderly Japanese people. *Journal of American Medical Directors Association, 14*, 518-524. doi:10.1016/j.jamda.2013.03.010

Singer, J., Trollor, J. N., Crawford, J., O, M. F., Baune, B. T., Brodaty, H., . . . Smith, E. (2013). The Association between Pulse Wave Velocity and Cognitive Function: The Sydney Memory and Ageing Study. *PLOS ONE, 8*(4), e61855-e61855. doi:10.1371/journal.pone.0061855

Skirbekk, V., Loichinger, E., & Weber, D. (2012). Variation in cognitive functioning as a refined approach to comparing aging across countries. *Proceedings of the National Academy of Sciences of the United States of America, 109*(3), 770-774. doi:10.1073/pnas.1112173109

Stern, Y. (2002). The concept of cognitive reserve: A catalyst for research. *Journal of Clinical and Experimental Neuropsychology, 25*(5), 589-593. doi:10.1076/jcen.25.5.589.14571

Stern, Y. (2006). Cognitive Reserve and Alzheimer Disease. *Alzheimer Disease & Associated Disorders, 20*(2), 112-117. doi:10.1097/01.wad.0000213815.20177.19

Suwanrada, W. (2008). Poverty and financial security of the elderly in Thailand. *Ageing International, 33*(1-4), 50-61. doi:10.1007/s12126-009-9030-y

Taboonpong, S., Chailungka, P., & Aassanangkornchai, S. (2008). Factors related to cognitive status among elders in southern Thailand. *Nursing & Health Sciences, 10*(3), 188-194. doi:10.1111/j.1442-2018.2008.00396.x

Tang-Wai, D. F., Knopman, D. S., Geda, Y. E., Edland, S. D., Smith, G. E., Ivnik, R. J., . . . Petersen, R. C. (2003). Comparison of the Short Test of Mental Status and the Mini-Mental State Examination in Mild Cognitive Impairment. *Archives of Neurology, 60*(12), 1777-1777. doi:10.1001/archneur.60.12.1777

Tardif, S., & Simard, M. (2011). Cognitive stimulation programs in healthy elderly: A review. *International Journal of Alzheimer's Disease, 2011*, 1-13. doi:10.4061/2011/378934

Teerawichitchainan, B., Pothisiri, W., & Long, G. T. (2015). How do living arrangements and intergenerational support matter for psychological health of elderly parents? Evidence from Myanmar, Vietnam, and Thailand. *Social*

Science & Medicine, 136-137, 106-116. doi:10.1016/J.SOCSCIMED.2015.05.019

Tesky, V. A., Thiel, C., Banzer, W., & Pantel, J. (2011). Effects of a group program to increase cognitive performance through cognitively stimulating leisure activities in healthy older subjects. *GeroPsych: The Journal of Gerontopsychology and Geriatric Psychiatry, 24*(2), 83-92. doi:10.1024/1662-9647/a000035

Thanakwang, K., & Soonthorndhada, K. (2011). Mechanisms by which social support networks influence healthy aging among thai community-dwelling elderly. *Journal of Aging and Health, 23*(8), 1352-1378. doi:10.1177/0898264311418503

Thaneerat, T., Tooreerach, U., Petrugs, B., Kimsao, P., Hongchukiet, K., & Deeduang, B. (2017). Development of Dementia Screening Test for Thai Elderly. *Journal of the Psychiatric Association of Thailand, 62*(2), 177-186.

Trongsakul, S., Lambert, R., Clark, A., Wongpakaran, N., & Cross, J. (2015). Development of the Thai version of Mini-Cog, a brief cognitive screening test. *Geriatrics & Gerontology International, 15*(5), 594-600. doi:10.1111/ggi.12318

Trott, C. T., Friedman, D., Ritter, W., Fabiani, M., & Snodgrass, J. G. (1999). Episodic priming and memory for temporal source: Event-related potentials reveal age-related differences in prefrontal functioning. *Psychology and Aging, 14*, 390-413.

Trovato, F., & Heyen, N. B. (2006). A varied pattern of change of the sex differential in survival in the G7 countries. *Journal of Biosocial Science, 38*(03), 391-391. doi:10.1017/S0021932005007212

Turner, A. D., Capuano, A. W., Wilson, R. S., & Barnes, L. L. (2015). Depressive Symptoms and Cognitive Decline in Older African Americans: Two scales and their factors HHS Public Access. *American Journal of Geriatric Psychiatry, 23*(6), 568-578. doi:10.1016/j.jagp.2014.08.003

United Nations. (2019). *2019 Revision of World Population Prospects*.

Vicerra, P. M. M., & Pothisiri, W. (2020a). Cognition-adjusted Dependency Ratio among later-life adults and the Role of Education. *Journal of Public Health and Development, 18*(2), 37-57.

Vicerra, P. M. M., & Pothisiri, W. (2020b). Trajectories of Cognitive Ageing among Thai Later-Life Adults: The Role of Education Using the Characteristics Approach. *Journal of Population and Social Sciences, 28*(4), 276-286.

Villar, F. (2012). Successful ageing and development: The contribution of generativity in older age. *Ageing and Society, 32*, 1087-1105. doi:10.1017/S0144686X11000973

Vos, T., Barber, R. M., Bell, B., Bertozzi-Villa, A., Biryukov, S., Bolliger, I., . . . Murray, C. J. L. (2015). Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet, 386*(9995), 743-800. doi:10.1016/S0140-6736(15)60692-4

Voss, M. W., Prakash, R. S., Erickson, K. I., Basak, C., Chaddock, L., Kim, J. S., . . . Kramer, A. F. (2010). Plasticity of brain networks in a randomized intervention trial of exercise training in older adults. *Frontiers in Aging Neuroscience, 2*, 1-32. doi:10.3389/fnagi.2010.00032

Wang, D., Zheng, J., Kurosawa, M., & Inaba, Y. (2009). Relationships between age and gender differentials in health among older people in China. *Ageing and Society, 29*(7), 1141-1154. doi:10.1017/S0144686X09008629

Warburton, D. E. R., Nicol, C. W., & Bredin, S. S. D. (2006). Health benefits of physical activity: The evidence. *Canadian Medical Association Journal, 174*(6), 801-809. doi:10.1503/cmaj.051351

Weber, D. (2016). Social engagement to prevent cognitive ageing? *Age and Ageing, 45*(4), 441-442. doi:10.1093/ageing/afw083

Weber, D., & Skirbekk, V. (2013). *A global perspective on cognitive function and educational attainment.* Paper presented at the Population Association of America.

Welmerink, D. B., Longstreth, W. T., Lyles, M. F., & Fitzpatrick, A. L. (2010). Cognition and the risk of hospitalization for serious falls in the elderly: results from the Cardiovascular Health Study. *Journals of Gerontology, Series A, Biological Sciences and Medical Sciences, 65*(11), 1242-1249.

Williams, D. R. (1999). Race, socioeconomic status, and health: the added effects of racism and discrimination. *Annals New York Academy of Sciences, 896*, 173-188.

Wilson, R. S., Hebert, L. E., Scherr, P. A., Barnes, L. L., De Leon, C. F. M., & Evans, D. A. (2009). Educational attainment and cognitive decline in old age. *Neurology, 72*(5), 460-465. doi:10.1212/01.wnl.0000341782.71418.6c

Wittgenstein Centre for Demography and Global Human Capital. (2018). Wittgenstein Centre Data Explorer Version 2.0 (Beta). Retrieved from http://www.wittgensteincentre.org/dataexplorer

Wolitzky-Taylor, K. B., Castriotta, N., Lenze, E. J., Stanley, M. A., & Craske, M. G. (2010). Anxiety disorders in older adults: a comprehensive review. *Depression and Anxiety, 27*(2), 190-211. doi:10.1002/da.20653

World Bank. (1994). *Averting the Old Age Crisis: Policies to Protect the Old and Promote Growth*. Retrieved from Oxford:

World Health Organization. (2002). *Active Ageing: A Policy Framework*. Retrieved from Geneva:

World Health Organization. (2006). *Neurological Disorders: Public Health Challenges*. Retrieved from

World Health Organization. (2012). *Dementia: A Public Health Priority*: World Health Organization.

World Health Organization. (2015). *The Epidemiology and Impact of Dementia: Current State and Future Trends*. Retrieved from http://www.who.int/mental_health/neurology/dementia/en/

World Health Organization. (2016). *Global health estimates 2015: DALYs by cause , age, sex by country and by region, 2000-2015*. Geneva: World Health Organization.

World Health Organization. (2017a). *Global action plan on the public health response to dementia*. Geneva: World Health Organization.

World Health Organization. (2017b). *Integrated care for older people: Guidelines on community-level interventions to manage declines in intrinsic capacity*. Retrieved from Geneva:

Wyatt, D. K. (1969). *The Politics of Reform in Thailand: Education in the Reign of King Chulalongkorn*: Yale University Press.

Yaffe, K., Falvey, C., Harris, T. B., Newman, A., Satterfield, S., Koster, A., . . . Simonsick, E. (2013). Effect of socioeconomic disparities on incidence of dementia among biracial older adults: prospective study. *BMJ, 347*, f7051-f7051. doi:10.1136/bmj.f7051

Yin, S., Zhu, X., Li, R., Niu, Y., Wang, B., Zheng, Z., . . . Li, J. (2015). Intervention-induced enhancement in intrinsic brain activity in healthy older adults. *Scientific Reports, 4*(1), 7309-7309. doi:10.1038/srep07309

Yuenyongchaiwat, K., Pongpanit, K., & Hanmanop, S. (2018). Physical activity and depression in older adults with and without cognitive impairment. *Dementia & Neuropsychologia, 12*(1), 12-18. doi:10.1590/1980-57642018dn12-010002

Zahodne, L. B., Manly, J. J., Smith, J., Seeman, T., & Lachman, M. E. (2017). Socioeconomic, health, and psychosocial mediators of racial disparities in cognition in early, middle, and late adulthood. *Psychology and Aging, 32*(2), 118-130. doi:10.1037/pag0000154

Zahodne, L. B., Stern, Y., & Manly, J. J. (2015). Differing effects of education on cognitive decline in diverse elders with low versus high educational attainment. *Neuropsychology, 29*(4), 649-657. doi:10.1515/jci-2013-0007

Zamani, H., Faroughi, P., & Ismail, N. (2016). Bivariate generalized Poisson regression model: Applications on health care data. *Empirical Economics, 51*, 1607-1621.

Zhang, M., Katzman, R., Salmon, D., Jin, H., Cai, G., Wang, Z., . . . Liu, W. T. (1990). The prevalence of dementia and Alzheimer's disease in Shanghai, China: Impact of age, gender, and education. *Annals of Neurology, 27*, 428-437.

Zhang, X., Dupre, M. E., Qiu, L., Zhou, W., Zhao, Y., & Gu, D. (2017). Urban-rural differences in the association between access to healthcare and health outcomes among older adults in China. *BMC Geriatrics, 17*(1), 1-11. doi:10.1186/s12877-017-0538-9

Zhu, S., Hu, J., & Efird, J. T. (2012). Role of social support in cognitive function among elders. *Journal of Clinical Nursing, 21*(15-16), 2118-2125. doi:10.1111/j.1365-2702.2012.04178.x

Zimmer, Z., & Amornsirisomboon, P. (2001). Socioeconomic status and health among older adults in Thailand: an examination using multiple indicators. *Social Science & Medicine, 52*, 1297-1311.

Zunzunegui, M.-V., Alvarado, B.-E., Bé, F., & Vissandjee, B. (2009). Explaining health differences between men and women in later life: A cross-city comparison in Latin America and the Caribbean. *Social Science & Medicine, 68*, 235-242. doi:10.1016/j.socscimed.2008.10.031

Zunzunegui, M.-V., Alvarado, B.-E., Del Ser, T., & Otero, A. (2003). Social networks, social integration, and social engagement determine cognitive decline in community-dwelling Spanish older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 58*(2), S93-S100. doi:10.1093/geronb/58.2.S93

VITA

NAME	Paolo Miguel Vicerra
DATE OF BIRTH	08 May 1986
PLACE OF BIRTH	Quezon City, Philippines
INSTITUTIONS ATTENDED	Chulalongkorn University International Institute for Applied Systems Analysis University of the Philippines Nihon University
HOME ADDRESS	Marikina City, Philippines
PUBLICATION	Vicerra, P. M. M., & Pothisiri, W. (2020). Cognition-adjusted Dependency Ratio among later-life adults and the Role of Education. Journal of Public Health and Development, 18(2):1-21. Vicerra, P. M. M., & Pothisiri, W. (2020). Trajectories of Cognitive Ageing among Thai Later-Life Adults: The Role of Education Using the Characteristics Approach. Journal of Population and Social Studies, 28(4): 276 - 286. Vicerra, P.M.M., Diokno, J.P., and Bongalos, J.B. (2018). Social Construction of the 'Environment': Role of Tertiary Institutes in Behaviour Transformation. Asia Pacific Higher Education Research Journal. 5(2): 61-70. Vicerra, P.M.M. (2018). Factors influencing immunisation schedule adherence and completion at the regional level in the Philippines. Kesmas: National Public Health Journal, 13(1), 1-7. Vicerra, P.M.M., Salvador, J.M., and Capili, Y.M. (2018). Disaster preparedness knowledge and action: Population development perspective. Asia Pacific Journal of Multidisciplinary Research. 6(1): 103-109. Vicerra, P.M.M. (2017). Teenage fertility and risk of pregnancy: Sociocultural correlates in the Philippines. Jati: Journal of Southeast Asian Studies: 22(1): 170-186.
AWARD RECEIVED	John Knodel Doctoral Fellowship at Chulalongkorn University APRU-Ageing Research Award