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Education Level, Monthly Per-Capita Expenditure, and Healthy Aging in the Older Indonesian Population: The Indonesia Family Life Survey 2007 and 2014

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In developed countries, the relationship between education level, wealth, and healthy aging have been found to be mediated by modifiable risk factors, such as obesity, physical activities, and smoking status. The present study was to investigate the association between education level, monthly per-capita expenditure (PCE), and healthy aging in the older Indonesian population, and to clarify modifiable risk factors that mediate this association. A 7-year prospective longitudinal study (2007-2014) was conducted on 696 older Indonesian individuals (≥ 50 years) living in 13 different provinces in Indonesia during the survey periods. Data on educational level, PCE, and modifiable risk factors were collected in 2007. Information on healthy aging was obtained in both 2007 and 2014. A multivariate-adjusted logistic regression model was used to estimate the odds ratio (ORs) and 95% confidence intervals (CIs) for healthy aging by education level and PCE. The mediating effects were estimated using a four-way effect decomposition. Out of 696 eligible subjects, 206 (29.6%) were judged as healthy aging in 2014. The OR (95% CI) for healthy aging for participants with a higher education level was 1.81 (1.23-2.65) compared with those with a lower education level, and no significant association was observed between PCE and healthy aging. An association was thus observed between education level and healthy aging, but not PCE. Importantly, the association between education level, PCE, and healthy aging does not appear to be mediated by the modifiable risk factors. Priorities in making health policy would be different between developed countries and developing countries.

Keywords: education level; healthy aging; Indonesia; mediation analysis; monthly per-capita expenditure
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Introduction

Indonesia is the fourth most populous country in the world. As of 2015, the population was nearly 260 million, and is estimated to rise to 295 million by 2030 (World Health Organization 2017). According to census data from Indonesia, the percentage of older persons among the total population increased rapidly, from 4.5% to 7.6%, between 1971 and 2010. This percentage is projected to continue increasing, reaching 15.8% by 2035 and 25.0% by 2050 (Adioetomo and Mujahid 2014; Central Bureau of Statistics 2018). This demographic change is becoming crucial for the Indonesia government to prepare the older society for healthy aging in the future (Adioetomo and Mujahid 2014).

Education level and household wealth, as representative measurements of socioeconomic status, are associated with healthy aging in Europe (Kollia et al. 2018). Previous studies in developed countries have suggested that the association between education level, household wealth, and healthy aging is influenced by certain modifiable risk factors (Oshio 2018), including body mass index (BMI), chronic disease, body pain, physical activity level, smoking

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status, health insurance status, marital status, and community participation (Hahn and Truman 2015; White et al. 2015; Oshio 2018; Kollia et al. 2018). To our knowledge, however, the association between education level, household wealth, and healthy aging in Indonesia has not been investigated. Therefore, to promote healthy aging among the older Indonesia population, identifying this association and any modifiable risk factors mediating has become an important issue.

For Indonesia as a developing country, the challenge of an aging population is more complex than that in developed countries. These complex challenges come from not only the different socioeconomic conditions but also the relative delay in enacting health policies (Kaneda and Zimmer 2007; Central Bureau of Statistics 2018). In Indonesia, 34.68% of the older population has not completed elementary school, and 44.45% live below the poverty line (i.e., at the bottom 40% of total per-capita expenditure [PCE]) (Central Bureau of Statistics 2018). Indonesia has not signed the World Health Organization (WHO) Framework Convention on Tobacco Control, and the number of elderly who smoke is quite high, at 24.26% (Central Bureau of Statistics 2018; Mboi et al. 2018). Health insurance protects the community in terms of health; however, because it was not implemented until 2014, its coverage still does not extend to the entire older population (Central Bureau of Statistics 2017; Mboi et al. 2018), which could adversely affect the potential of healthy aging in Indonesia. For these reasons, in the present study, we consider whether modifiable risk factors between education level, monthly PCE, and healthy aging among older Indonesians differ from those among older populations in developed countries. Therefore, the aims of the present study were to investigate the association between education level, monthly PCE, and healthy aging in the older Indonesian population, and to clarify any modifiable risk factors that may mediate on the association between education level, monthly PCE and healthy aging.

Methods

The Indonesia Family Life Survey (IFLS)

The Indonesia Family Life Survey (IFLS) is an ongoing longitudinal study that has been conducted in 1993, 1997, 2000, 2007, and 2014. The present study used the data of IFLS 4 in 2007 and IFLS 5 in 2014. The design of the IFLS study has been described in detail elsewhere (Frankenberg et al. 1995; Strauss et al. 2009, 2016). In brief, in 1993, The IFLS sampling frame was stratified on provinces and urban/rural areas; then, based on these strata, the subjects were selected randomly. Provinces were selected to maximize the representation of the population, capture the socioeconomic diversity of Indonesia, and balance the cost-effectiveness (Frankenberg et al. 1995).

The IFLS sample represented about 83% of the Indonesian population living in 13 of the 27 total provinces. The survey randomly selected 321 areas in the 13 provinces, which represented urban-rural areas, geographical and ethnic comparisons (Frankenberg et al. 1995). Within a selected area, a household was randomly selected; afterward, an individual age ≥ 50 years and their spouse in the household also were randomly selected from the household members outside the head of the household and their spouses and children aged 0-14 years old. Furthermore, asked to provide the information below.

The IFLS survey involved face-to-face interviews with adult participants. Questionnaires were used to collect individual information, such as education level, monthly PCE, self-assessed health status, physical ability to carry out activities of daily living, cognitive capacity, body weight, height, chronic diseases, body pain, physical activity level, smoking status, health insurance status, marital status, and community participation and so on (Strauss et al. 2016).

Study population

The data used in the present study were obtained from the Indonesia Family Life Survey (IFLS) 2007 and 2014 because information on the outcome variables for measuring healthy aging in our study were available only in the IFLS 4 (Strauss et al. 2009) and IFLS 5 (Strauss et al. 2016).

The IFLS 4 survey was conducted between November 2007 and mid-July 2008 and the IFLS 5 from September 2014 until April 2015 (Strauss et al. 2009, 2016). The eligible population for the IFLS 4 comprised 7,040 men and women aged ≥ 50 years, among whom, 6,077 responded to the questionnaire that formed our study (Fig. 1).

Among the respondents to the IFLS 4, we excluded 565 with missing data for date of birth, 489 who were aged < 50 years based on birth date, 111 with missing data for exposure (9 for education level and 102 for monthly PCE), 818 with missing data for cognitive capacity, 168 with missing data for modifiable risk factors (including BMI, community participation, physical activity level, and/or health insurance status), and 2,824 who were categorized as unhealthy aging (defined as unhealthy self-assessed health status, physical limitations in terms of carrying out activities of daily living, and/or poor cognitive capacity) in the IFLS 4, leaving 1,102 healthy aging older individuals .

Next, we excluded one participant who was ineligible for the IFLS 5, 102 who had died, 99 who had moved out of the IFLS areas before the IFLS 5, 98 with missing data on self-assessed health, and 106 with missing data on cognitive capacity, finally leaving 696 participants eligible for analysis. This 7-year longitudinal study was carried out between 2007 and 2014. In 2014, healthy aging was confirmed for 206 (29.6%) individuals.

Assessment of exposure (education level and monthly PCE)

Education level was assessed using the following questions: 1) “Have you ever attended school?”, to which respondents answered “yes” or “no”; 2) “What is the highest education level attained?”, to which the answer was cat-

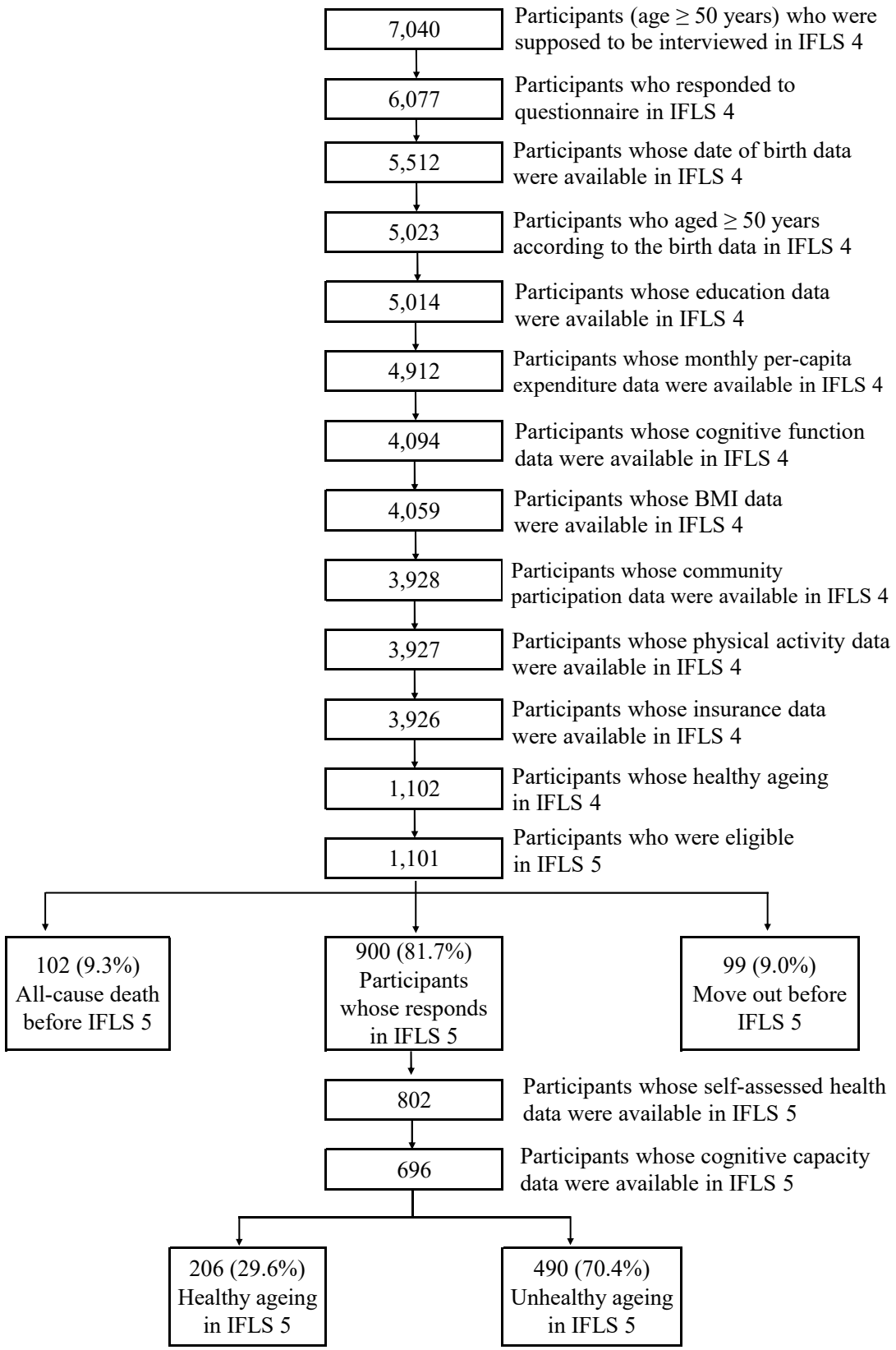

Fig. 1. Flow Chart of the study participants: education level, monthly PCE and healthy aging, Indonesia Family Life Survey (IFLS) 2007 and 2014.

egorized as elementary, junior high school or equivalent, senior high school or equivalent, or college or university (D1, D2, D3). From 1984 to 1994, 6-year education (age 7-12 years) was compulsory in Indonesia (UNESCO International Bureau of Education 2011; Suratno 2014), and all Indonesians were required to complete elementary education (i.e., primary education according to the International Standard Classification of Education [ISCED] 2011 (UNESCO Institute for Statistics 2012)). The method used to calculate mediating effects requires exposure to be classified into two categories (VanderWeele 2014; Discacciati et al. 2018); therefore, we classified education level into two groups: below lower-secondary education (no schooling or primary education) or lower-secondary education and above (junior high school or equivalent and above).

Monthly PCE was calculated as monthly total household expenditure divided by the number of household members. Household expenditures were categorized as follows: 1) food expenditure; 2) non-food consumption: frequently purchased goods and services (i.e., electricity/phone/water, personal toiletries, transportation, recreation and entertainment, and other); 3) non-food expenditure: less frequently purchased goods and services (i.e., clothing, furniture, medicine, taxes, ceremonies, and other); 4) education (i.e., tuition, uniforms, and transportation); or 5) housing (i.e., rent). Household expenditures in the IFLS have been described in detail elsewhere (Witoelar 2009). We defined low monthly PCE as the bottom 40% of total monthly PCE according to the definition of poor by the World Bank and WHO (World Health Organization and World Bank 2014). The monthly PCE in the IFLS data was assessed in Indonesian rupiah (Rp), then converted into US dollars (USD) at 2007 exchange rates (1 USD = 9,141 Rp) (OECD 2019). As a result, monthly PCE was categorized into two groups: ≤ 43 USD or > 43 USD.

Assessment of outcome (healthy aging)

Healthy aging was assessed based on three variables: self-assessed health status, physical ability to carry out activities of daily living, and cognitive capacity.

Self-assessed health status was determined with the question "In general, how is your health?", to which respondents answered "excellent", "good", "fair", or "poor". The responses were then categorized into two groups: healthy (combining the categories "excellent" and "good") or unhealthy (combining the categories "fair" and "poor") (Cao and Rammohan 2016).

Physical ability to carry out activities of daily living was determined based on nine physical abilities: "to carry a heavy load (like a pail of water) for 20 m", "to draw a pail of water from a well", "to walk for 1 km", "to walk for 5 km", "to sweep the house flood yard", "to bow, squat, or kneel", "to walk across the room", "to stand up from sitting on the floor without help", and "to stand up from sitting in a chair without help". For each activity, respondents answered "easily", "with difficulty", or "unable to do". We then categorized the answers into two groups: functional healthy (easy to conduct all activities) or functionally limited (combining "with difficulty" and "unable to do" one or more task) (Kaneda and Zimmer 2007).

Cognitive capacity was assessing based on the immediate and delayed recall of 10 words. The interviewers would read 10 words slowly, with intervals of about 2 s between each word. After the interviewer finished reading all 10 words, the participants were asked to recall the words ("immediate recall"). Twenty minutes after the initial word presentation, participants were asked to recall the words again ("delayed recall"). The possible number of correct answers for both the immediate and delayed recall tasks was 10; thus, total scores ranged from 0 to 20. We classified the answer into two groups: better cognitive function (score ≥ 7) or worse cognitive function (score < 7) (Takayama 2010; Maharani and Tampubolon 2016).

We defined healthy aging as having healthy self-assessed health, no physical limitations in terms of carrying out activities of daily living, and good cognitive capacity (Hamer et al. 2014; Cao and Rammohan 2016). Based on these definitions, we grouped the participants into two categories: healthy aging or unhealthy aging.

Assessment of modifiable risk factors

Based on previous studies (Hamer et al. 2014; Hahn and Truman 2015; White et al. 2015; Oshio 2018; Kollia et al. 2018), BMI, chronic disease, body pain, physical activity level, smoking status, community participation, health insurance status, and marital status were selected as modifiable risk factors in regard to the association between education level and healthy aging.

BMI was calculated as body weight (in kilograms) divided by the square of body height (in meters). For Asian populations, the cutoff point for public health action is 23.0 kg/m^2 according to the World Health Organization (2004); therefore, we divided the participants into two BMI groups: < 23.0 kg/m^2 or ≥ 23.0 kg/m^2. Chronic diseases were classified as yes (i.e., participants who had any disease) or none (i.e., participants who had no diseases), and body pain was categorized as yes (i.e., any type of pain) or none (i.e., no type of pain).

Physical activity level was assessed according to the short version of the International Physical Activity Questionnaire (IPAQ) (IPAQ Research Committee 2005) and defined as follows: moderate-high or low. Smoking status was classified as current nonsmoker (never and former) or current smoker. Health insurance status was classified as yes (i.e., respondents who had health insurance) or none (i.e., respondents who did not have health insurance). Marital status was classified as married or other (single, separated, divorced, or widowed). Community participation was divided into two groups: participation (i.e., respondents who participated in at least one type of community activity) or non-participation (i.e., respondents who never participated in any of the four types of community activi-

ties).

More details about the assessment of modifiable risk factors were described in the IFLS 4 (Strauss et al. 2009).

Ethics approval

The IFLS data used in the present study are publicly available. The surveys and procedures of the IFLS study were reviewed and approved by institutional review boards (IRBs) at the RAND Corporation in the US and the University of Gadjah Mada (UGM) in Indonesia. Written informed consent was obtained from all participants before data collection began.

Statistical analysis

Baseline characteristics were evaluated using one-factor analysis of variance for continuous variables and the chi-squared test for categorical variables. A multivariate-adjusted logistic regression model was used to estimate the odd ratios (ORs) and 95% confidence intervals (CIs) for healthy aging according to education level and monthly PCE using below lower-secondary education and ≤ 43 USD, respectively, as reference values. Model 1 was age- (50-59, 60-69, ≥ 70 years) and sex-adjusted. Model 2 was adjusted for model 1 added regions (Sumatra, Java-Bali, West Nusa Tenggara, South Kalimantan, or South Sulawesi) and areas (urban or rural) (more details about the regions and areas were described in the IFLS 4 (Strauss et al. 2009)). To examine whether the association between education level and healthy aging was attributable to monthly PCE, model 3 was adjusted for model 2 added monthly PCE (≤ 43 or > 43 USD). While to verify the association between monthly PCE and healthy aging was attributable to education level, model 3 was further adjusted for model 2 added education level (below lower-secondary education or lower-secondary education and above).

Logistic regression models were also used to calculate the ORs and 95% CIs for the modifiable risk factors on healthy aging. Model 1 was age- and sex-adjusted. Model 2 was further adjusted for regions, areas, education level, monthly PCE and all modifiable risk factors simultaneously.

To estimate the mediating effects, we used four-way effect decomposition (VanderWeele 2014), where the total effect (overall effect of exposure on healthy aging) was decomposed into: 1) a controlled direct effect (component of the total excess relative risk due to the effect of exposure on healthy aging when the modifiable risk factors are fixed to the referent level [i.e., better level]); 2) reference interaction (component of the total excess relative risk due to the interaction only between exposure and modifiable risk factors); 3) mediated interaction (component of the total excess relative risk due to both the mediating effects of modifiable risk factors and the interaction between exposure and the modifiable risk factors); and 4) pure indirect effect or mediated main effect (component of the total excess relative risk due to the mediating effects of modifiable risk factors only). Logistic regression models were used for both the outcomes and the mediators. Age (50-59, 60-69, ≥ 70 years), sex, region, area, monthly PCE, and education level were controlled in the models as confounding factors. The modifiable risk factors were categorized into dichotomous variables: BMI (< 23.0 kg/m^2 [reference] or ≥ 23.0 kg/m^2), chronic disease (yes or none [reference]), body pain (yes or none [reference]), physical activity level (low or moderate-high [reference]), smoking status (current or nonsmoker [reference]), health insurance status (yes [reference] or no), marital status (married [reference] or other), and community participation (participation in any community activity [reference] or non-participation). The mediating effect for each of the modifiable risk factors was estimated by considering them one at a time.

The logistic regression model was carried out using the SAS statistical software package (version 9.4; SAS Institute Inc.), and the mediation effects using Stata (Stata/MP 14.2; Stata Corp LLC.) and the med4way package (Discacciati et al. 2018). All statistical tests were two-sided. P values < 0.05 were considered to be statistically significant.

Results

Out of 696 eligible subjects, 206 (29.6%) were judged as healthy aging in IFLS 5.

Baseline characteristics

Table 1 shows the baseline characteristics of the participants according to education level. Participants with a higher education level were younger and more likely to be men, to live in Java-Bali, to live in an urban area, to have higher monthly PCE, to have a higher BMI, to have hypertension and diabetes, to participate in community meeting, and to have health insurance. Those with a higher education level also less likely to live in West Nusa Tenggara, South Kalimantan, and South Sulawesi, to have low monthly PCE, to have hip pain, and to have a moderate-high physical activity level.

Table 2 shows the baseline characteristics of the participants according to monthly PCE. Participants with a higher monthly PCE were more likely to live in an urban area, to have a higher education level, to have a higher BMI, to have hypertension, diabetes, and coronary heart disease, to participate in community meeting, and to have health insurance. They were also less likely to have a moderate-high physical activity level and be a current smoker.

Education level, monthly PCE, and healthy aging

Table 3 shows the association between education level, monthly PCE, and healthy aging (n = 696). The multivariate-adjusted OR (95% CI) for healthy aging was 1.81 (1.23-2.65) for those with a higher education level (Model 3: P < 0.01), as compared with the participant with a lower education level. However, no evidence of an association was observed between PCE and healthy aging (Model 3, OR [95% CI] 0.88 [0.60-1.30]).

Table 1. Baseline characteristics of the participants by education level in the Indonesia Family Life Survey (IFLS) 2007 (n = 696).

	Education level		*P* value[a]
	Below lower-secondary education	Lower-secondary education and above	
No. of all participants	365	331	
Age, y (mean ± SD[b])	56.6 ± 5.3	55.8 ± 4.7	< 0.05
Males (%)	60.6	72.8	< 0.01
Region (%)			
Sumatra	15.3	13.0	0.38
Java-Bali	64.1	74.3	< 0.01
West Nusa Tenggara, South Kalimantan, South Sulawesi	20.6	12.7	< 0.05
Urban area (%)[c]	44.7	76.4	< 0.01
Per-capita expenditure, USD[d] (mean ± SD)	50 ± 52	99 ± 102	< 0.01
Low per-capita expenditure[e] (%)	58.1	20.2	< 0.01
Body Mass Index, kg/m^2 (mean ± SD)	22.3 ± 4.2	24.2 ± 4.0	< 0.01
Chronic diseases (%)			
Hypertension	11.8	17.5	< 0.05
Diabetes	0.6	5.1	< 0.01
Coronary Heart Diseases	1.1	2.1	0.28
Stroke	0.3	0.0	0.34
Depression	0.3	0.0	0.34
Body pain (%)			
Head	24.7	20.9	0.23
Neck	5.5	5.7	0.88
Shoulder	5.8	5.1	0.72
Arm	4.7	8.2	0.06
Wrist/hand/fingers	3.3	6.0	0.08
Back/lower back	9.6	7.9	0.42
Hip	7.7	3.9	< 0.05
Knee	10.1	7.9	0.29
Ankle/foot/toes	4.9	7.3	0.20
Physical activity level, moderate-high (%)[f]	95.1	80.1	< 0.01
Current smoker (%)	45.2	42.0	0.39
Participation in community activities (%)			
Community meeting	29.9	55.9	< 0.01
Voluntary labor	40.8	43.2	0.53
Program to improve the village/neighborhood	32.1	33.5	0.68
Religious activities	76.7	76.1	0.86
Health insurance, yes (%)	23.6	48.6	< 0.01
Married (%)	82.7	87.9	0.05

[a]Obtained using the chi-squared test for categorical variables and one-factor analysis of variance for continuous variables.
[b]SD, standard deviation.
[c]Central Bureau of Statistics (BPS) Indonesia definition (population density of 5,000 persons per km^2; 25% or less of the households work in the agricultural sector; and having eight or more specific kinds of urban facilities, including primary schools, junior high schools, senior high schools, hospitals, maternity [mother-child] hospitals, primary health care centers, roads [to accommodate three- and four-wheeled motorized vehicles], telephones, post offices, markets, cinemas, banks, shopping centers, factories, and restaurants).
[d]USD at 2007 exchange rates (1 USD = 9,141 Rp).
[e]In the bottom 40% of monthly per-capita expenditure (about ≤ 43 USD / month).
[f]International Physical Activity Questionnaire (IPAQ) categories: moderate: 1) ≥ 3 days of vigorous activity for ≥ 20 min per day; or 2) ≥ 5 days of moderate-intensity activity and/or walking of ≥ 30 min per day; or 3) ≥ 5 days of any combination of walking, moderate-intensity, or vigorous-intensity activities achieving a minimum of 600 MET-min/week; and high: 1) vigorous-intensity activity for ≥ 3 days accumulating ≥ 1,500 MET-min/week; or 2) ≥ 7 days of any combination of walking, moderate-intensity, or vigorous-intensity activities accumulating ≥ 3,000 MET-min/week).

Table 2. Baseline characteristics of the participants by monthly per-capita expenditure, in the Indonesia Family Life Survey (IFLS) 2007 (n = 696).

	Monthly per-capita expenditure (USD)[b]		*P* value[a]
	≤ 43	> 43	
No. of all participants	279	417	
Age, y (mean ± SD[c])	56.4 ± 5.4	56.1 ± 4.7	0.38
Males (%)	67.4	65.7	0.65
Region (%)			
Sumatra	12.2	15.6	0.21
Java-Bali	67.7	69.8	0.57
West Nusa Tenggara, South Kalimantan, South Sulawesi	20.1	14.6	0.06
Urban area (%)[d]	43.0	71.0	< 0.01
Lower-secondary education and above (%)	24.0	63.3	< 0.01
Education level (%)[e]			
No schooling	11.1	2.6	
Primary education	64.9	34.1	
Lower secondary education	13.6	17.3	< 0.01
Upper secondary education	9.0	27.1	
University	1.4	18.9	
Body Mass Index, kg/m^2 (mean ± SD)	22.2 ± 4.2	23.8 ± 4.1	< 0.01
Chronic diseases (%)			
Hypertension	10.8	17.0	< 0.05
Diabetes	0.7	4.1	< 0.05
Coronary Heart Disease	0.4	2.4	< 0.05
Stroke	0.0	0.2	0.41
Depression	0.4	0.0	0.22
Body pain (%)			
Head	22.6	23.0	0.89
Neck	5.0	6.0	0.58
Shoulder	4.7	6.0	0.45
Arm	6.5	6.2	0.91
Wrist/hand/fingers	3.6	5.3	0.30
Back/lower back	8.2	9.1	0.69
Hip	6.1	5.8	0.85
Knee	9.3	8.9	0.84
Ankle/foot/toes	6.1	6.0	0.96
Physical activity, moderate-high (%)[f]	95.3	83.0	< 0.01
Current smoker (%)	50.5	39.1	< 0.01
Participation in community activities (%)			
Community meeting	36.2	46.3	< 0.05
Voluntary labor	40.5	42.9	0.53
Program to improve the village/neighborhood	36.9	30.0	0.06
Religious activities	76.0	76.7	0.82
Health insurance, yes (%)	27.6	40.8	< 0.01
Married (%)	85.0	85.4	0.88

[a]Obtained using the chi-squared test for categorical variables and one-factor analysis of variance for continuous variables.
[b]Total monthly household expenditure divided by the number of household members. USD at 2007 exchange rates (1 USD = 9,141 Rp).
[c]SD, standard deviation.
[d]Central Bureau of Statistics (BPS) Indonesia definition (population density of 5,000 persons per km^2; 25% or less of the households work in the agricultural sector; and having eight or more specific kinds of urban facilities, including primary schools, junior high schools, senior high schools, hospitals, maternity [mother-child] hospitals, primary health care centers, roads [to accommodate three- and four-wheeled motorized vehicles], telephones, post offices, markets, cinemas, banks, shopping centers, factories, and restaurants).
[e]The International Standard Classification of Education (ISCED) 2011.
[f]International Physical Activity Questionnaire (IPAQ) categories: moderate: 1) ≥ 3 days of vigorous activity for ≥ 20 min per day; or 2) ≥ 5 days of moderate-intensity activity and/or walking of ≥ 30 min per day; or 3) ≥ 5 days of any combination of walking, moderate-intensity, or vigorous-intensity activities achieving a minimum of 600 MET-min/week; and high: 1) vigorous-intensity activity for ≥ 3 days accumulating ≥ 1,500 MET-min/week; or 2) ≥ 7 days of any combination of walking, moderate-intensity, or vigorous-intensity activities accumulating ≥ 3,000 MET-min/week).

Table 3. Association between education level, monthly per-capita expenditure, and healthy aging in the Indonesia Family Life Survey (IFLS) 2007 and 2014 (n = 696).

	Education level		*P* value[a]	Monthly per-capita expenditure (USD)[b]		*P* value[a]
	Below lower-secondary education	Lower-secondary education and above		≤ 43	> 43	
No. of participants (n = 696)	365	331		279	417	
Healthy aging, n (%)	81 (22.2)	125 (37.8)		75 (26.9)	131 (31.4)	
Crude	1.00 (Ref.)	2.13 (1.53-2.97)	< 0.01	1.00 (Ref.)	1.25 (0.89-1.74)	0.20
Model 1[c]	1.00 (Ref.)	1.91 (1.36-2.68)	< 0.01	1.00 (Ref.)	1.19 (0.85-1.68)	0.31
Model 2[d]	1.00 (Ref.)	1.73 (1.21-2.48)	< 0.01	1.00 (Ref.)	1.08 (0.75-1.55)	0.68
Model 3[e]	1.00 (Ref.)	1.81 (1.23-2.65)	< 0.01	1.00 (Ref.)	0.88 (0.60-1.30)	0.52

[a]Logistic regression model.
[b]Total monthly household expenditure divided by the number of household members. USD at 2007 exchange rates (1 USD = 9,141 Rp).
[c]Model 1 was adjusted for age (50-54, 55-59, 60-64, 65-69, and ≥ 70 years) and sex.
[d]Model 2 was adjusted for Model 1 plus region (Sumatra, Java-Bali, West Nusa Tenggara, South Kalimantan, or South Sulawesi) and area (urban or rural).
[e]Model 3 was adjusted for Model 2 plus monthly PCE (≤ 43 or > 43 USD) [when exposure was education level] and education level (below lower-secondary or lower-secondary and above) [when exposure was monthly per-capita expenditure].

Modifiable risk factors and healthy aging

Table 4 shows the association between modifiable risk factors and healthy aging. The probability of healthy aging was significantly higher among participants who did not have any body pain, as compared with those who did; the multivariate-adjusted ORs (95% CIs) were 2.16 (1.52-3.07) in model 1, and 2.06 (1.44-2.96) in model 2. However, no other modifiable risk factors had a significant effect on healthy aging.

Mediating effects of modifiable risk factors by education level

Table 5 shows the mediating effects of different modifiable risk factors between education level and healthy aging. Compared with participants with a lower education level, those with a higher education level had a higher probability of healthy aging (coefficient of total excess relative risk (tereri) = total effect risk ratio − 1 = 0.822, 0.883, 0.869, 0.814, 0.909, 0.842, 0.816, and 0.807 for BMI, chronic disease, body pain, physical activity level, smoking status, health insurance status, marital status, and community participation, respectively).

Additionally, when each modifiable risk factor was fixed at the reference level (i.e., the better or healthier level), except for community participation, compared with participants with a lower education level, those with a higher education level had an increased probability of healthy aging (coefficient of excess relative risk due to the controlled direct effect [ereri_cde] = 1.107, 1.163, 1.235, 0.898, 1.152, 1.464, and 0.830, and 0.801 for BMI, chronic disease, body pain, physical activity level, smoking status, health insurance status, and marital status, respectively). While for community participation, compared with a lower education level, those with a higher education level, coefficient of ereri_cde slightly decrease = 0.801).

Even though tereri and ereri_cde were significant ($P < 0.05$). However, no significant mediating effect (indicate by excess relative risk due to the pure indirect effect [ereri_pie] was not significant) was observed for any modifiable risk factor on the association between education level and healthy aging.

Mediating effects of modifiable risk factors by monthly PCE

Table 6 shows the mediating effects of different modifiable risk factors between monthly PCE and healthy aging. No significant mediating effect (indicate by ereri_pie was not significant) was observed for any modifiable risk factor on the association between monthly PCE and healthy aging.

Discussion

In this population-based longitudinal study, we investigated the association between education level, monthly PCE, and healthy aging in the older Indonesian population and attempted to clarified any modifiable risk factors that may mediate this association. We found that education level was associated with healthy aging; our finding was consistent with a previous study (White et al. 2015). By contrast, monthly PCE was not associated with healthy aging among older Indonesian individuals. No significant mediating effects for predefined modifiable risk factors were observed for education level or monthly PCE on healthy aging. To the best of our knowledge, the present study is the first study to investigate the association between education level, monthly PCE, and healthy aging, as well as any possible mediating factors, in the older Indonesian population.

Table 4. Association between modifiable risk factors and healthy aging in the Indonesia Family Life Survey (IFLS) 2007 and 2014 (n = 696)[a].

Modifiable risk factors	No. of participants	Healthy aging, n (%)	Model 1[b] (95% CI)	Model 2[c] (95% CI)
Body Mass Index, kg/m^2				
< 23.0	371	110 (29.7)	1.00 (0.71-1.39)	1.13 (0.78-1.64)
≥ 23.0	325	96 (29.5)	1.00 (Reference)	1.00 (Reference)
Chronic diseases				
None	572	176 (30.8)	1.37 (0.87-2.16)	1.37 (0.84-2.23)
Any disease	124	30 (24.2)	1.00 (Reference)	1.00 (Reference)
Body pain				
None	388	141 (36.3)	2.16 (1.52-3.07)	2.06 (1.44-2.96)
Any pain	308	65 (21.1)	1.00 (Reference)	1.00 (Reference)
Physical activity				
Moderate-high	612	180 (29.4)	0.92 (0.56-1.53)	1.14 (0.66-1.99)
Low	84	26 (31.0)	1.00 (Reference)	1.00 (Reference)
Smoking status				
Never-former	392	105 (26.8)	0.99 (0.67-1.46)	0.96 (0.63-1.45)
Current	304	101 (33.2)	1.00 (Reference)	1.00 (Reference)
Health insurance				
Yes	247	79 (32.0)	1.21 (0.86-1.71)	1.09 (0.75-1.58)
No	449	127 (28.3)	1.00 (Reference)	1.00 (Reference)
Marital status				
Married	593	181 (30.5)	0.89 (0.52-1.51)	0.93 (0.54-1.62)
Others	103	25 (24.3)	1.00 (Reference)	1.00 (Reference)
Community participation				
Any participated	610	181 (29.7)	0.95 (0.57-1.59)	0.92 (0.54-1.62)
None	86	25 (29.1)	1.00 (Reference)	1.00 (Reference)

[a]Logistic regression model.
[b]Model 1 was adjusted for age (50-54, 55-59, 60-64, 65-69, and ≥ 70 years) and sex.
[c]Model 2 was adjusted for Model 1 plus region (Sumatra, Java-Bali, West Nusa Tenggara, South Kalimantan, or South Sulawesi), area (rural or urban), Body Mass Index (< 23.0 or ≥ 23.0 kg.m^2), chronic disease (yes or no), body pain (yes or no), physical activity level (low or moderate-high), smoking status (current or former/never), community participation (any or none), health insurance (yes or no), marital status (married or other), educational level (below lower-secondary education or lower-secondary education and above), and monthly PCE (≤ 43 or > 43 USD).

Our findings showed that monthly PCE was not associated with healthy aging. Previous studies among Indonesian individuals have reported that income does not have a significant effect on self-assessed health status (Chung 2004), and that Indonesians with a higher socioeconomic status have a higher probability of experiencing health complaints such as obesity and hypertension (Wijayanti et al. 2018; Sudharsanan 2019). The reason might be because Indonesians with a higher socioeconomic status consume more fats, salt, and processed foods and have a lower physical activity level (Allen et al. 2017). Our baseline characteristics showed that participants with a higher monthly PCE were more likely to have a higher BMI and hypertension, but less likely to have a moderate-high physical activity level.

Interestingly, although education level was positively associated with healthy aging, no significant mediating effects were identified in regard to the association between education level and healthy aging. One possible reason may be that in the present study, except for body pain, no association was observed between predefined modifiable risk factors and healthy aging. This result is quite different from the situation in developed countries (Hamer et al. 2014; Hahn and Truman 2015; White et al. 2015; Oshio 2018; Kollia et al. 2018). Prior studies in European countries have found that non-smoker and marriage were associated with cognitive function (a component of healthy aging) (Mousavi-Nasab et al. 2012; Kollia et al. 2018). In addition, other studies in the Netherlands and the US reported that engaging in social activities and having health insurance were associated with higher rates of healthy self-reported health status (also a component of healthy aging) (Hadley and Waidmann 2006; Sirven and Debrand 2008).

Regarding body pain, a previous study in Europe reported that individuals with a higher education level were less likely than those with a lower education level to report having chronic pain (Saastamoinen et al. 2005), and that body pain was significantly associated with the healthy

Table 5. Mediation analyses of the association between education level (education level: below-lower secondary [reference] vs. lower-secondary and above) and healthy aging in the Indonesia Family Life Survey (IFLS) 2007 and 2014 (n = 696)[a].

Modifiable risk factors	Effect[b]	Coefficient	*P* value	95% Confidence interval	
Body Mass Index, kg/m^2					
≥ 23.00 vs. < 23.00 (Ref.)	tereri	0.822	0.022	0.118	1.525
	ereri_cde	1.107	0.031	0.099	2.114
	ereri_intref	–0.178	0.362	–0.561	0.205
	ereri_intmed	–0.099	0.369	–0.315	0.117
	ereri_pie	–0.008	0.889	–0.116	0.100
Chronic disease					
Yes vs. None (Ref.)	tereri	0.883	0.018	0.149	1.617
	ereri_cde	1.163	0.008	0.306	2.020
	ereri_intref	–0.187	0.023	–0.349	–0.026
	ereri_intmed	–0.115	0.088	–0.248	0.017
	ereri_pie	0.022	0.543	–0.049	0.094
Body pain					
Yes vs. None (Ref.)	tereri	0.869	0.024	0.116	1.623
	ereri_cde	1.235	0.032	0.104	2.365
	ereri_intref	–0.363	0.142	–0.846	0.121
	ereri_intmed	–0.002	0.965	–0.072	0.068
	ereri_pie	–0.001	0.965	–0.053	0.051
Physical activities					
Low vs. Moderate-high (Ref.)	tereri	0.814	0.023	0.115	1.512
	ereri_cde	0.898	0.018	0.156	1.640
	ereri_intref	–0.041	0.381	–0.132	0.051
	ereri_intmed	–0.079	0.384	–0.257	0.099
	ereri_pie	0.036	0.643	–0.116	0.188
Smoking status					
Current vs. Non-current (Ref.)	tereri	0.909	0.018	0.153	1.665
	ereri_cde	1.152	0.013	0.248	2.056
	ereri_intref	–0.261	0.195	–0.656	0.134
	ereri_intmed	0.055	0.300	–0.049	0.158
	ereri_pie	–0.036	0.276	–0.100	0.029
Health insurance					
No vs. Yes (Ref.)	tereri	0.842	0.021	0.125	1.559
	ereri_cde	1.464	0.007	0.409	2.518
	ereri_intref	–0.774	0.054	–1.561	0.014
	ereri_intmed	0.246	0.066	–0.016	0.508
	ereri_pie	–0.095	0.131	–0.217	0.028
Marital status					
No vs. Yes (Ref.)	tereri	0.816	0.022	0.116	1.516
	ereri_cde	0.830	0.025	0.104	1.556
	ereri_intref	–0.014	0.876	–0.184	0.156
	ereri_intmed	0.001	0.887	–0.013	0.015
	ereri_pie	–0.002	0.786	–0.013	0.010
Community participation					
None vs. Any (Ref.)	tereri	0.807	0.023	0.112	1.503
	ereri_cde	0.801	0.027	0.093	1.508
	ereri_intref	0.009	0.927	–0.184	0.202
	ereri_intmed	–0.001	0.929	–0.020	0.018
	ereri_pie	–0.001	0.821	–0.012	0.009

tereri, total excess relative risk; ereri_cde, excess relative risk due to controlled direct effect; ereri_intref, excess relative risk due to reference interaction; ereri_intmed, excess relative risk due to mediated interaction; ereri_pie, excess relative risk due to pure indirect effect.

[a]Logistic regression model.

[b]Adjusted for age (50-54, 55-59, 60-64, 65-69, and ≥ 70 years), sex, region (Sumatra, Java-Bali, West Nusa Tenggara, South Kalimantan, or South Sulawesi), area (urban or rural), and monthly PCE (≤ 43 or > 43 USD).

Table 6. Mediation analyses of the association between monthly per-capita expenditure (≤ 43 USD [reference] vs. > 43 USD] and healthy aging in the Indonesia Family Life Survey (IFLS) 2007 and 2014 (n = 696)[a].

Modifiable risk factors	Effect[b]	Coefficient	*P* value	95% Confidence interval	
Body Mass Index, kg/m^2					
≥ 23.00 vs. < 23.00 (Ref.)	tereri	–0.132	0.450	–0.474	0.210
	ereri_cde	–0.245	0.310	–0.718	0.228
	ereri_intref	0.120	0.369	–0.142	0.381
	ereri_intmed	0.033	0.395	–0.043	0.110
	ereri_pie	–0.040	0.241	–0.107	0.027
Chronic diseases					
Yes vs. None (Ref.)	tereri	–0.102	0.567	–0.452	0.248
	ereri_cde	–0.016	0.940	–0.424	0.392
	ereri_intref	–0.062	0.331	–0.188	0.063
	ereri_intmed	–0.026	0.391	–0.085	0.033
	ereri_pie	0.002	0.947	–0.046	0.049
Body pain					
Yes vs. None (Ref.)	tereri	–0.171	0.327	–0.513	0.171
	ereri_cde	–0.380	0.144	–0.890	0.130
	ereri_intref	0.223	0.073	–0.021	0.467
	ereri_intmed	0.017	0.480	–0.030	0.064
	ereri_pie	–0.031	0.450	–0.112	0.050
Physical activities					
Low vs. Moderate-high (Ref.)	tereri	–0.129	0.463	–0.473	0.215
	ereri_cde	–0.037	0.842	–0.399	0.326
	ereri_intref	–0.076	0.267	–0.211	0.058
	ereri_intmed	–0.082	0.295	–0.235	0.071
	ereri_pie	0.066	0.379	–0.081	0.213
Smoking status					
Current vs. Non-current (Ref.)	tereri	–0.063	0.742	–0.440	0.314
	ereri_cde	0.182	0.474	–0.316	0.679
	ereri_intref	–0.255	0.083	–0.542	0.033
	ereri_intmed	0.052	0.228	–0.032	0.136
	ereri_pie	–0.042	0.249	–0.114	0.029
Health insurance					
No vs. Yes (Ref.)	tereri	–0.100	0.581	–0.456	0.256
	ereri_cde	0.394	0.225	–0.242	1.029
	ereri_intref	–0.502	0.036	–0.972	–0.033
	ereri_intmed	0.021	0.521	–0.043	0.086
	ereri_pie	–0.012	0.533	–0.051	0.027
Marital status					
No vs. Yes (Ref.)	tereri	–0.116	0.508	–0.461	0.228
	ereri_cde	–0.102	0.584	–0.467	0.263
	ereri_intref	–0.015	0.795	–0.124	0.095
	ereri_intmed	–0.001	0.893	–0.008	0.007
	ereri_pie	0.001	0.882	–0.009	0.011
Community participation					
None vs. Any (Ref.)	tereri	–0.115	0.516	–0.461	0.231
	ereri_cde	–0.188	0.295	–0.541	0.164
	ereri_intref	0.094	0.246	–0.065	0.252
	ereri_intmed	–0.033	0.321	–0.100	0.033
	ereri_pie	0.013	0.493	–0.025	0.052

tereri, total excess relative risk; ereri_cde, excess relative risk due to controlled direct effect; ereri_intref, excess relative risk due to reference interaction; ereri_intmed, excess relative risk due to mediated interaction; ereri_pie, excess relative risk due to pure indirect effect.

[a]Logistic regression model.

[b]Adjusted for age (50-54, 55-59, 60-64, 65-69, and ≥ 70 years), sex, region (Sumatra, Java-Bali, West Nusa Tenggara, South Kalimantan, or South Sulawesi), area (urban or rural), and education level (below lower-secondary or lower-secondary and above).

aging index score (Wilkie et al. 2013). By contrast, among Indonesian individuals, although body pain was inversely associated with healthy aging, the prevalence of pain was similar between different education levels.

The present study also found that participants with a higher education level tended to have a higher BMI, were more likely to have a chronic disease, and were less likely to have a moderate-high physical activity level. By contrast, previous studies in developed countries have found that individuals with a higher education level tended to have a lower BMI (Roskam and Kunst 2008; Hermann et al. 2011) were less likely to have a chronic disease (Mielck et al. 2012), and were more likely to engage in regular vigorous activity (Shaw and Spokane 2008). In addition, normal BMI was associated with healthy life expectancy (Stenholm et al. 2017), while participation in moderate or vigorous physical activity was associated with healthy aging (Hamer et al. 2014), and not having a chronic disease was associated with a better quality of life (Barile et al. 2013; Wijers et al. 2019).

Taking all the above into consideration, the different distributions of mediating factors between exposure groups and the lack of an observed association between mediating factors and healthy aging may be the main reason that factors that have been recognized as mediators in developed countries failed to be identified as mediators in Indonesia. There was difference in modifiable risk factors on the association between education level, monthly PCE, and healthy aging in developed countries and such developing countries. It is suggested that the results obtained in developed countries may not be applicable to Indonesia as developing countries.

The strengths of the present study are as follows. First, this was the first known longitudinal study to investigate the role of modifiable risk factors in the association between education level, monthly PCE, and healthy aging among the older adult Indonesian population. Second, as national survey data were used, the findings can be considered highly representative.

However, this study also had several limitations. First, the information in regard to modifiable risk factors might have changed between the IFLS 4 and the IFLS 5. Second, some unmeasured mediators (e.g., working conditions, retirement benefits, health knowledge, and social support) may not have been considered. Third, in view of the possible bias caused by excluding individuals with missing data for modifiable risk factors, 4,094 participants, including those for whom such data were missing, were analyzed, but the association between education level, monthly PCE, and healthy aging did not change substantially. Therefore, the association between education level, monthly PCE, and healthy aging is unlikely to be the result of selection bias.

In conclusion, education level was significantly associated with healthy aging among the older adult Indonesian population, whereas monthly PCE was not. However, no mediating effects were observed for the predefined modifiable risk factors for education level and monthly PCE on healthy aging. Additional studies are needed to identify other important potential mediators for healthy aging in Indonesia. The present results also suggest that priorities in making health policy would be different between developed countries and developing countries.

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Authors Contributions

D.N. and S.Z designed the research; D.N., S.Z. and A.D. analyzed the data; D.N. wrote the paper; S.Z., A.D., Y.T., Y.L., Y.S. and I.T. gave constructive suggestions; D.N. had primary responsibility for the final content. All authors read and approved the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

References

Adioetomo, S.M. & Mujahid, G. (2014) Monograph series No. 1: Indonesia on the threshold of population ageing. https://indonesia.unfpa.org/en/publications/monograph-series-no-1-indonesia-threshold-population-ageing [*Accessed*: April 18, 2019].

Allen, L., Williams, J., Townsend, N., Mikkelsen, B., Roberts, N., Foster, C. & Wickramasinghe, K. (2017) Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review. *Lancet Global Health*, **5**, e277-e289.

Barile, J.P., Thompson, W.W., Zack, M.M., Krahn, G.L., Horner-Johnson, W. & Bowen, S.E. (2013) Multiple chronic medical conditions and health-related quality of life in older adults, 2004-2006. *Prev. Chronic Dis.*, **10**, E162-E173.

Cao, J. & Rammohan, A. (2016) Social capital and healthy ageing in Indonesia. *BMC Public Health*, **16**, 631-644.

Central Bureau of Statistics (2017) Elderly Population Statistics 2016. https://www.bps.go.id/publication/2017/11/17/107752aa20f3f8cb08d9dabe/statistik-penduduk-lanjut-usia-2016.html [*Accessed*: March 18, 2019] (in Indonesian).

Central Bureau of Statistics (2018) Elderly Population Statistics 2018. https://www.bps.go.id/publication/2018/12/21/eadbab6507c06294b74adf71/statistik-penduduk-lanjut-usia-2018.html [*Accessed*: May 14, 2019] (in Indonesian).

Chung, W. (2004) Income Inequality and Health: Evidence from Indonesia. https://webarchive.nla.gov.au/tep/102621 [*Accessed:* March 1, 2018].

Discacciati, A., Bellavia, A., Lee, J.J., Mazumdar, M. & Valeri, L. (2018) Med4way: a Stata command to investigate mediating and interactive mechanisms using the four-way effect decomposition. *Int. J. Epidemiol.*, **48**, 15-20.

Frankenberg, E., Karoly, L.A., Gertler, P., Achmad, S., Agung, I.G.N., Hatmadji, S.H. & Sudharto, P. (1995) The 1993 Indonesian Family Life Survey: Overview and Field Report. https://www.rand.org/pubs/drafts/DRU1195z1.html [*Accessed*: November 1, 2018].

Hadley, J. & Waidmann, T. (2006) Health insurance and health at age 65: implications for medical care spending on new Medicare beneficiaries. *Health Serv. Res.*, **41**, 429-451.

Hahn, R.A. & Truman, B.I. (2015) Education improves public health and promotes health equity. *Int. J. Health Serv.*, **45**, 657-678.

Hamer, M., Lavoie, K.L. & Bacon, S.L. (2014) Taking up physical activity in later life and healthy ageing: the English longitudinal study of ageing. *Br. J. Sports Med.*, **48**, 239-243.

Hermann, S., Rohrmann, S., Linseisen, J., May, A.M., Kunst, A., Besson, H., Romaguera, D., Travier, N., Tormo, M.J., Molina, E., Dorronsoro, M., Barricarte, A., Rodriguez, L., Crowe, F.L., Khaw, K.T., et al. (2011) The association of education with body mass index and waist circumference in the EPIC-PANACEA study. *BMC Public Health*, **11**, 169-181.

IPAQ Research Committee (2005) Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) – Short and Long Forms. http://www.ipaq.ki.se [*Accessed*: May 29, 2018].

Kaneda, T. & Zimmer, Z. (2007) Education, gender, and functional transitions among Indonesian elderly. *J. Cross Cult. Gerontol.*, **22**, 303-322.

Kollia, N., Caballero, F.F., Sanchez-Niubo, A., Tyrovolas, S., Ayuso-Mateos, J.L., Haro, J.M., Chatterji, S. & Panagiotakos, D.B. (2018) Social determinants, health status and 10-year mortality among 10,906 older adults from the English longitudinal study of aging: the ATHLOS project. *BMC Public Health*, **18**, 1357-1366.

Maharani, A. & Tampubolon, G. (2016) National economic development status may affect the association between central adiposity and cognition in older adults. *PLoS One*, **11**, e0148406.

Mboi, N., Surbakti, I.M., Trihandini, I., Elyazar, I., Smith, K.H., Ali, P.B., Kosen, S., Flemons, K., Ray, S.E., Cao, J., Glenn, S.D., Miller-Petrie, M.K., Mooney, M.D., Ried, J.L., Ningrum, D.N.A., et al. (2018) On the road to universal health care in Indonesia, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*, **392**, 581-591.

Mielck, A., Reitmeir, P., Vogelmann, M. & Leidl, R. (2012) Impact of educational level on health-related quality of life (HRQL): results from Germany based on the EuroQol 5D (EQ-5D). *Eur. J. Public Health*, **23**, 45-49.

Mousavi-Nasab, S.M., Kormi-Nouri, R., Sundstrom, A. & Nilsson, L.G. (2012) The effects of marital status on episodic and semantic memory in healthy middle-aged and old individuals. *Scand. J. Psychol.*, **53**, 1-8.

OECD (2019) Exchange rates (indicator). https://data.oecd.org/conversion/exchange-rates.htm [*Accessed*: April 12, 2019].

Oshio, T. (2018) Widening disparities in health between educational levels and their determinants in later life: evidence from a nine-year cohort study. *BMC Public Health*, **18**, 278-288.

Roskam, A.J. & Kunst, A.E. (2008) The predictive value of different socio-economic indicators for overweight in nine European countries. *Public Health Nutr.*, **11**, 1256-1266.

Saastamoinen, P., Leino-Arjas, P., Laaksonen, M. & Lahelma, E. (2005) Socio-economic differences in the prevalence of acute, chronic and disabling chronic pain among ageing employees. *Pain*, **114**, 364-371.

Shaw, B.A. & Spokane, L.S. (2008) Examining the association between education level and physical activity changes during early old age. *J. Aging Health*, **20**, 767-787.

Sirven, N. & Debrand, T. (2008) Social participation and healthy ageing: an international comparison using SHARE data. *Soc. Sci. Med.*, **67**, 2017-2026.

Stenholm, S., Head, J., Aalto, V., Kivimaki, M., Kawachi, I., Zins, M., Goldberg, M., Platts, L.G., Zaninotto, P., Magnusson Hanson, L.L., Westerlund, H. & Vahtera, J. (2017) Body mass index as a predictor of healthy and disease-free life expectancy between ages 50 and 75: a multicohort study. *Int. J. Obes. (Lond.)*, **41**, 769-775.

Strauss, J., Witoelar, F. & Sikoki, B. (2016) The Fifth Wave of the Indonesia Family Life Survey (IFLS 5): Overview and Field Report. https://www.rand.org/pubs/working_papers/WR1143z1.html [*Accessed*: November 1, 2018].

Strauss, J., Witoelar, F., Sikoki, B. & Wattie, A.M. (2009) The Fourth Wave of the Indonesia Family Life Survey (IFLS 4): Overview and Field Report. https://microdata.worldbank.org/index.php/catalog/1044/download/20909 [*Accessed*: November 1, 2018].

Sudharsanan, N. (2019) The association between socioeconomic status and adult mortality in a developing country: evidence from a nationally representative longitudinal survey of Indonesian adults. *J. Gerontol. B. Psychol. Sci. Soc. Sci.*, **74**, 484-495.

Suratno, T. (2014) The education system in Indonesia at a time of significant changes. http://ries.revues.org/3814 [*Accessed*: April 15, 2019].

Takayama, Y. (2010) A delayed recall battery as a sensitive screening for mild cognitive impairment follow-up study of memory clinic patients after 10 year. *J. Med. Dent. Sci.*, **57**, 177-184.

UNESCO Institute for Statistics (2012) International Standard Classification of Education ISCED 2011. http://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf [*Accessed*: October 1, 2018].

UNESCO International Bureau of Education (2011) Indonesia: World Data on Education. http://www.ibe.unesco.org/fileadmin/user_upload/Publications/WDE/2010/pdf-versions/Indonesia.pdf [*Accessed*: April 12, 2019].

VanderWeele, T.J. (2014) A unification of mediation and interaction: a 4-way decomposition. *Epidemiology*, **25**, 749-761.

White, C.M., St John, P.D., Cheverie, M.R., Iraniparast, M. & Tyas, S.L. (2015) The role of income and occupation in the association of education with healthy aging: results from a population-based, prospective cohort study. *BMC Public Health*, **15**, 1181-1192.

Wijayanti, W., Pratomo, D.S. & Khusaini, M. (2018) The effects of socio-economic factors on health of elderly in East Java. *Scientific Annals of Economics and Business*, **65**, 205-213.

Wijers, I.G.M., Ayala, A., Rodriguez-Blazquez, C., Rodriguez-Laso, A., Rodriguez-García, P., Prados-Torres, A., Rodriguez-Rodriguez, V. & Forjaz, M.J. (2019) The disease burden morbidity assessment in older adults and its association with mortality and other health outcomes. *Eur. J. Ageing*, **16**, 193-203.

Wilkie, R., Tajar, A. & McBeth, J. (2013) The onset of widespread musculoskeletal pain is associated with a decrease in healthy ageing in older people: a population-based prospective study. *PLoS One*, **8**, e59858.

Witoelar, F. (2009) Note on the Construction of the IFLS Consumption Expenditure Aggregates. https://dokumen.tips/documents/ifls-consumption-expenditure-aggregatespdf.html [*Accessed*: June 18, 2018].

World Health Organization (2004) Appropriate body-mass index for Asian populations and its implications for policy and inter-

vention strategies. *The Lancet*, **363**, 157-163.
World Health Organization (2017) State of health inequality: Indonesia.
http://www.who.int/iris/handle/10665/259685
[*Accessed*: December 21, 2017].
World Health Organization; World Bank (2014) Monitoring progress towards universal health coverage at country and global levels: Framework, measures and targets.
https://www.who.int/healthinfo/universal_health_coverage/report/2014/en/
[*Accessed*: March 6, 2019].