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What factors influence healthy aging? A person-centered approach among older adults in Taiwan

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Aim: The present study aimed to identify the health profiles of older adults by using latent class analysis to investigate health heterogeneity and to determine what factors predicted healthy aging among an oldest-old sample cohort that was followed up for 14 years in Taiwan.

Methods: Data were drawn from five waves (carried out in 1993, 1996, 1999, 2003 and 2007) of the Taiwan Longitudinal Study on Aging to examine the changes in health heterogeneity in a nationally representative oldest-old cohort of Taiwanese. Overall, data from a total of 11 145 observations of 3155 older adults were considered. The influential factors predicting health changes were analyzed by using a generalized estimating equation.

Results: The results showed that four health profiles were identified among the aging population observed in the Taiwan Longitudinal Study on Aging. With increasing age, the combined effects of the physical functioning, cognitive and emotional health, and comorbidities of older adults significantly impact their health changes. Apart from health deteriorating with age and sex disparities, educational and economic status, health behaviors, and social participation at the individual level were found to be the robust factors in predicting healthy aging.

Conclusions: In considering what factors impact healthy aging, we suggest that a person-centered approach would be useful and critical for policy makers to understand the compositions of health profiles and the influencing factors in view of a life-course perspective. Based on the factors identified as influencing healthy aging at the individual level, it is imperative from a policy-making perspective to maximize opportunities for healthy aging. Geriatr Gerontol Int 2016; ••: ••–••.

Keywords: elderly people, health heterogeneity, healthy aging, person-centered.

Introduction

Aging with chronic disease has become the norm in many countries, and the number of people living with chronic diseases for decades is increasing worldwide.[1] By the end of 2014, approximately 12% of the total population was aged 65 years and older.[2] That number is expected to rise to 14% by 2017 and to 20% by 2025. Among the older adults aged 65 years and older, the percentage of people aged 80 years and older is expected to increase most rapidly, from approximately 24.4% in 2010 to 44% in 2060.[3] According to the statistics, more than 80% of older adults in Taiwan suffered from chronic diseases.[4] Also, the prevalence of disabilities is estimated to be 14.95% among older adults aged 65 years and older, and 48.59% among aged 85 years and older.[5]

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Because of the fact that most older adults suffer from multiple chronic diseases in later life, the new definition of health provided by the World Health Organization (WHO) is becoming more widely accepted. In 1999, the WHO redefined health in terms of its relationship with aging, emphasizing that good health is vital for the maintenance of an acceptable quality of life in older individuals, and to ensure the continued contributions of older persons to society.[6] The active-aging concept, along with synonymous concepts such as healthy aging and successful aging, has been actively promoted by WHO, which encourages older adults to engage in the process of growing older without growing old through the maintenance of physical, social and spiritual activities throughout a lifetime.[7] Swedish National Institute of Public Health (SNIPH, 2007) also showed that healthy aging is "the process of optimizing opportunities for physical, social and mental health to enable older people to take an active part in society without discrimination and to enjoy an independent and good quality of life".[8] Both WHO (2002) and SNIPH (2007) pay greater attention to improving the situation of older adults against a wide range of objectives relating to their individual well-being.[7,8]

Although it is widely acknowledged that there is no agreed on definition of the successful aging,[9] previous research mentioned that it might be conceptualized as a developmental and maintenance process in which age is associated with the attainment of at least optimal functioning, and well-being that is consistent with normal aging.[10] The Baltimore Longitudinal Study of Aging study (2010) regarding healthy aging in a longitudinal study showed that "normal" aging can be distinguished from disease.[11] It has been helpful in understanding what people can do to increase their likelihood of experiencing good health (narrowly defined) as they age, then take into account the influences of broader social contextual factors in various cultures.[12] In fact, people all age differently. In terms of change and development, there are more differences among older people than among younger people, and that the heterogeneous group of older people actually consumes a disproportionate share of services has been well documented.[13] Understanding why some people are resistant to disease and functional decline, and identifying ways to stay healthy are the challenges for the future.[11] Based on the health heterogeneity of older adults, we tried to focus on healthy aging with the implication that later life can be a time of sustained health and vitality rather than merely a time of ill health and dependency.[14] This includes the goal of maintaining positive functioning for as long as possible and subjective health.[15] Then, we examined the socioeconomic and behavior contexts that might play a determinative role in influencing healthy aging.

When measuring health among older adults, however, multiple health indicators sometimes relate differently to various dimensions of health. As Crimmins showed, not all dimensions of health change in the same direction at the same time.[16] Trends in any one of them are not necessarily evidence of health trends overall.[16,17] As also specified by the WHO, the overall aging of society has placed a greater emphasis on the importance of holistic health.[7] Therefore, it is increasingly important to use a person-centered approach, which takes multiple observed health indicators into account to describe health heterogeneity more comprehensively. A better understanding of the health heterogeneity of older adults by a person-centered approach is necessary to adequately evaluate the policy options and interventions aimed at improving the health-related quality of life for older people.

To deal with health heterogeneity and its change over time, the present study sought to identify the health profiles of older adults by using latent class analysis (LCA). LCA is a "person-centered" approach designed to divide the population under study into latent subpopulations (i.e. classes) that share a distinct interpretation pattern of relationships among indicators.[18] Identifying health profiles by using such a person-centered approach presents some means of identifying and quantifying interindividual variability in health status in order to comprehend the dynamic of older adults' health and social needs.[13] It can combine both the objective and subjective health indicators and to our knowledge, few previous studies in Taiwan have examined health profiles of older adults and their changes over time by utilizing a longitudinal follow-up study of a national population.

Methods

Data source and study sample

The data for the present study were taken from the Survey of Health and Living Status of the Elderly in Taiwan, also known as the Taiwan Longitudinal Study on Aging (TLSA). The TLSA is a nationally representative survey of Taiwanese older adults, with the initial respondents, who were given the group name "cohort B," having been selected from the population aged 60 years and older in 1989.[19] Follow-up interviews with the same respondents were completed every 3–4 years thereafter, specifically in 1993, 1996, 1999, 2003 and 2007. Given that the aim of the present study was focused on older adults aged 65 years and older, and that some of the survey questions we used had different wording in 1989 than were used in later waves, we focused on the analyses of cohort B from the surveys of 1993–2007, when the relevant questions were asked consistently. Data have been weighted according to age strata to represent the population before LCA.

Health profile identification

Based on the aforementioned literature review, it is hypothesized that healthy aging was associated with the heterogeneity of health profiles change overtime. The selection of the health indicators was based on the discrimination of each indicator and the criteria of health latent classes of older adults. In total, 18 health indicators were used to determine health profiles through LCA. This variety of health indicators represents the multidimensional characteristics of the health concept and the complexities involved in measuring it. The health indicators chosen in the study were related to need factors, as measured by physical and mental health conditions (such as depression), sensory limitations, and functional impairments viewed as the potential endogenous factors that influence the health of older adults and also their subjectively rated health. The yes/no indicators of chronic conditions were identified for which individuals acknowledged that the diagnosis had been confirmed by physicians. Sensory limitations (also indicated on a yes/no basis) included self-declared problems with hearing and vision. Self-rated health, an overall measure that incorporates several dimensions of health, was determined by the interviewee's subjective perceptions (as indicated by bad/not bad responses). Cognitive problems were measured with the Mini-Mental State Examination (with scores ≤23 indicating cognitive impairment).

Depression was examined with the short version of the Center for Epidemiologic Studies Depression Scale (with scores ≥10 indicating depression). Functional disability (yes/no) was defined as a need for assistance with activities of daily living (ADL) and instrumental ADL (IADL); and mobility (which referred to difficulty in carrying out upper and lower limb movements).

The data on sociodemographic and economic variables collected in each wave of interviews in the study included age, sex, religion, education, marital status, location, economic status, smoking and drinking behavior. Social participation, which was also determined on a yes/no basis, with attendance at any social activity listed in the TLSA question set regarding learning and recreational activities was taken as an indication of social participation.

Statistical analysis

The data and statistical analyses in the study were divided into two parts. First, LCA was used to carry out the classification of health profiles (i.e. latent classes) of older adults. The model fit of the LCA was assessed with Bayesian information criteria and Lo–Mendell–Rubin likelihood ratio tests. The Lo–Mendell–Rubin likelihood ratio test compares improvement in fit ($P < 0.001$) between sequential class models through approximation of the likelihood ratio tests distribution. An entropy measure was used to assess how well the model predicted class membership given the observed health indicators ranging from 0 to 1, and higher values are preferred. Bivariate residual statistics served to confirm local independence. As we aimed to follow the changes in the health profiles of the elderly cohort over time, data from 3155 persons interviewed in 1993 and a total of 11 145 person-wave samples (from cohort B) were analyzed in LCA to categorize health heterogeneity. For the five follow-up waves, the method of multiple imputations was used for those health indicators with missing data. Second, generalized estimating equation was used to identify the influential factors predicting changes in health profiles. Overall, 3118 samples from 1993 and 10 546 person-wave samples in total were analyzed in this manner after data cleaning of the samples with missing data for the independent variables.

Results

Basic information for the study samples

Table 1 details the health status of the study samples (for cohort B) in each wave of the TLSA survey, and the probabilities of the health indicators explored showed that older people's health deteriorated further as they aged. For example, the percentage of older adults who reported difficulty with five to six ADL increased from 3.84% in 1993 to 17.43% in 2007.

Table 2 lists the sociodemographic characteristics of the 3118 older respondents with complete data for the baseline year 1993. In terms of their health and social behaviors, 29% reported smoking and 18% reported a habit of drinking alcohol. Regarding social participation, approximately 40% attended at least one social activity (e.g. a physical or recreational activity etc.) per week.

Health heterogeneity of older adults

The health profiles of the older adults are identified in Table 3, which shows the relationship between the respondents' latent health profiles and their health indicators. In the present study, 18 of the aforementioned health indicators were selected in the final LCA model. A comparison of LCA model fit statistics showed a significant reduction in the likelihood ratio tests with an increasing number of classes. The adjusted Bayesian information criteria suggested that the four-class model best fit the data (Bayesian information criteria: 187 184.154; $P < 0.0001$), including good quality of classification (entropy: 0.80) and no identification problems (condition number: 0.521E-06).

The first column in Table 3 reports sample proportions for the health indicators. The entries in the other columns are the probabilities (λ) of profile-specific health indicators. A label is assigned to each profile based on comparisons of the conditional health indicator probabilities. Four health profiles were distinguished, and these health statuses were numbered from 4 to 1, to indicate a range from relatively healthy status to the worst status. Individuals in the first profile (class 1) were characterized as the "Frail" group, as they had the highest probabilities of both physical impairment (with high difficulties in ADL and IADL for 5 or more activities, $\lambda = 0.582$ and 1.00, and high mobility problems, $\lambda = 0.986$ and 0.997 in upper and lower limbs, respectively) and high cognitive impairment ($\lambda = 0.878$). They also had various diseases, multiple chronic conditions, high probabilities of depression ($\lambda = 0.763$) and low self-rated health ($\lambda = 0.752$), problems which, taken together, made them the most vulnerable. This group of older adults accounted for 5.55% in 1993. The second profile (class 2) was termed the "Functional impairment" group because of their relatively high probabilities of requiring care assistance ($\lambda = 0.744$ in IADL difficulties for 3–4 activities) and having difficulties in mobility ($\lambda = 0.967$ and 1.00 in upper and lower limbs, respectively), along with relatively high rates of cognitive problems ($\lambda = 0.539$), depression ($\lambda = 0.578$) and poor self-rated health ($\lambda = 0.690$). The third profile (class 3) included individuals with fairly high probabilities of various diseases, but a low probability of cognitive problems ($\lambda = 0.197$), no difficulty in carrying out ADL ($\lambda = 0.000$) and limited difficulties in IADL ($\lambda = 0.058$ and 0.010). We labeled this group of older adults the "High comorbidity" group. The last profile (class 4) was the "Relatively healthy" profile. These people were comparatively

Table 1 Characteristics of study samples in each wave of the Taiwan Longitudinal Study on Aging survey (cohort B)

$n = 11\,145$	1993 (Wave 2) $n = 3155$		1996 (Wave 3) $n = 2669$		1999 (Wave 4) $n = 2310$		2003 (Wave 5) $n = 1743$		2007 (Wave 6) $n = 1268$	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Hypertension	926	29.35	832	31.17	895	38.74	791	45.38	617	48.66
Diabetes	318	10.08	317	11.88	369	15.97	295	16.92	218	17.19
Renal disease	217	6.88	206	7.72	198	8.57	174	9.98	134	10.57
Heart disease	594	18.83	523	19.60	523	22.64	464	26.62	363	28.63
Stroke	213	6.75	168	6.29	196	8.48	186	10.67	134	10.57
Respiratory disease	415	13.15	343	12.85	362	15.67	283	16.24	198	15.62
Joint and musculoskeletal problems	557	17.65	580	21.73	528	22.86	442	25.36	300	23.66
Cataracts	813	25.77	690	25.85	805	34.85	824	47.27	686	54.10
Gastric disease	380	12.04	394	14.76	467	20.22	355	20.37	282	22.24
ADL difficulties										
3–4 activities	39	1.24	45	1.69	70	3.03	69	3.96	53	4.18
5–6 activities	121	3.84	143	5.36	174	7.53	185	10.61	221	17.43
IADL difficulties										
3–4 activities	325	10.30	321	12.03	336	14.55	303	17.38	265	20.90
5 or more activities	195	6.18	233	8.73	246	10.65	247	14.17	259	20.43
Functional limits (upper)	1131	35.85	1013	37.95	1583	68.53	1354	77.68	1023	80.68
Functional limits (lower)	1689	53.53	1437	53.84	1569	67.92	1356	77.80	1061	83.68
Depression	884	28.02	827	30.99	712	30.82	497	28.51	438	34.54
Sensory (hearing) problems	412	13.06	341	12.78	447	19.35	436	25.01	351	27.68
Sensory (vision) problems	670	21.24	592	22.18	557	24.11	481	27.60	363	28.63
Self-rated health (bad)	781	24.75	951	35.63	927	40.13	747	42.86	551	43.45
Cognitive impairments	867	27.48	657	24.62	617	26.71	538	30.87	522	41.17

The analysis included only cohort B (the earliest cohort) of the Taiwan Longitudinal Study on Aging. The data collected from the 3155 respondents in 1993 (wave 2) were used as the baseline for later follow ups, and the longitudinal data contained 11 145 person-waves in total from 1993 to 2007. ADL, activities of daily living; IADL, instrumental activities of daily living.

less likely to report chronic diseases and comorbid conditions, cognitive disorders ($\lambda = 0.109$) or depression ($\lambda = 0.098$), and they had low probabilities of disability (with no or minimal difficulties for both ADL [$\lambda = 0.000$] and IADL, $\lambda = 0.005$ and 0.001, respectively) and relatively few functional limitations ($\lambda = 0.055$ and 0.190 in mobility). Approximately half (49.81%) of the older adults in 1993 were categorized into this group, and the percentage of respondents with the frail and functional impairment statuses were relatively few (5.55% for class 1 and 10.58% for class 2).

The changes in each health profile over the five waves are shown in Figure 1 and Table 4. As Figure 1 clearly shows, with the increasing age of the sample cohort, the percentage of respondents in class 4 decreased from 50% in 1993 to 17% in 2007, whereas the percentages in class 1 and 2 increased, meaning that the health of the respondents changed negatively overall during the 14 years of follow up. Table 4 shows the four transition probability matrixes that compared the percentages in each class from one year to the next year. For example, the proportion of class 1 in each wave increased from 5.85% ($n = 184$) in 1993 to 8.03% ($n = 202$) in 1996, 10.53% ($n = 227$) in 1999, 13.62% ($n = 220$) in 2003, an increase of approximately 2–3% per year. For class 4, apart from fewer respondents (22%) shifting to class 3 in 1996, the percentage of those shifting to class 3 in each wave was approximately 37.6%, and those that stayed in class 4 decreased gradually from 60.7% in 1996 to 44% in 1999 and 37.6% in 2007. It also showed that 10% or less in each class were lost to follow up in each wave.

Influencing factors predicting healthy aging

Generalized estimating equation analysis was carried out for the 3118 elderly respondents with complete data, and the influencing factors predicting changes in health profiles are shown in Table 5. It is found that, not surprisingly, age accounts for a significant factor, meaning that health changes negatively with increasing age in general. In addition, sex was also found to be an influential factor in that females showed worse health profiles than their male counterparts. In the study, it was found that with increasing time (wave), the health profiles change negatively (for example, $\beta = -0.174$, $P < 0.001$; $\beta = -0.477$, $P < 0.001$; $\beta = -0.775$, $P < 0.001$; $\beta = -1.046$, $P < 0.001$ in the full model). After

Table 2 Characteristics of older adults in four health classes in 1993 (baseline sample)

	Total Means (SD)/*n* (%)	Class 1 (*n* = 173)	Class 2 (*n* = 330)	Class 3 (*n* = 1062)	Class 4 (*n* = 1553)	*P*-value
Age (years)						<0.0001
Mean	71.71 (5.74)	77.09 (6.93)	74.91 (6.54)	71.92 (5.64)	70.29 (4.74)	
Range	64–94	64–94	64–94	64–94	64–92	1 > 2 > 3 > 4
Sex						<0.0001
Male	1760 (56%)	65 (38%)	100 (30%)	505 (48%)	1090 (70%)	
Female	1358 (44%)	108 (62%)	230 (70%)	557 (52%)	463 (30%)	
Marital status						<0.0001
Married	1963 (63%)	75 (43%)	151 (46%)	642 (60%)	1095 (71%)	
Not married	1155 (37%)	98 (57%)	179 (54%)	420 (40%)	458 (29%)	
Ethnicity						<0.0001
Taiwanese	1897 (61%)	123 (71%)	241 (73%)	647 (61%)	886 (57%)	
Hakka	494 (16%)	31 (18%)	45 (14%)	175 (16%)	243 (16%)	
Mainlander	677 (22%)	15 (9%)	32 (10%)	216 (20%)	414 (27%)	
Others	50 (2%)	4 (2%)	12 (4%)	24 (2%)	10 (1%)	
Religion						0.2186
Daoism	1810 (58%)	68 (39%)	188 (57%)	640 (60%)	914 (59%)	
Buddhism	591 (19%)	21 (12%)	64 (19%)	210 (20%)	296 (19%)	
Other	224 (7%)	5 (3%)	24 (7%)	86 (8%)	109 (7%)	
None	493 (16%)	79 (46%)	54 (16%)	126 (12%)	234 (15 %)	
Location						<0.0001
City/urban	1539 (49%)	75 (43%)	145 (44. %)	504 (47%)	815 (52%)	
Town/rural	1579 (51%)	98 (57%)	185 (56%)	558 (53%)	738 (48%)	
Education						<0.0001
Illiterate	1258 (40%)	115 (66%)	227 (69%)	477 (45%)	439 (28%)	
Elementary school	1278 (41%)	49 (28%)	87 (26%)	433 (41%)	709 (46%)	
Junior high school and above	582 (19%)	9 (5%)	16 (5%)	152 (14%)	405 (26%)	
Yearly income (NTD)						<0.0001
<60 000	1138 (36%)	125 (72%)	208 (63%)	404 (38%)	401 (26%)	
60 000–120 000	656 (21%)	23 (13%)	61 (18%)	257 (24%)	315 (20%)	
120 000–240 000	734 (24%)	11 (6%)	44 (13 %)	259 (24%)	420 (27%)	
>240000	590 (19%)	14 (8%)	17 (5%)	142 (13%)	417 (27%)	
Smoking						<0.0001
Yes	905 (29%)	24 (14%)	47 (14 %)	250 (24%)	584 (38%)	
No	2213 (71%)	149 (86%)	283 (86%)	812 (76 %)	969 (62%)	

(*Continues*)

Table 2 (Continued)

	Total Means (SD)/*n* (%)	Class 1 (*n* = 173)	Class 2 (*n* = 330)	Class 3 (*n* = 1062)	Class 4 (*n* = 1553)	*P*-value
Alcohol						<0.0001
Yes	550 (18%)	3 (2%)	17 (5 %)	133 (13%)	397 (26%)	
No	2568 (82%)	170 (98%)	313 (95%)	929 (87%)	1156 (74%)	
Social participation						<0.0001
Yes	1240 (40%)	21 (12%)	84 (25%)	403 (38%)	732 (47%)	
No	1878 (60%)	152 (88%)	246 (75 %)	659 (62%)	821 (53%)	

$n = 3118$. The number of respondents varied as a result of variations in the amount of missing data in the covariates. The *P*-values shown were determined by examining the statistical significance of each covariate among the four health classes.

controlling for age and sex in model 1, individuals' sociodemographic characteristics, including marital status (specifically, those who were single, divorced or widowed), religion (specifically, those without religion) and location (specifically, those living in rural areas), were found to significantly influence changes in health profiles ($\beta = -0.071$, $P < 0.05$; $\beta = -0.288$, $P < 0.001$; $\beta = -0.11$, $P < 0.001$). In model 2, when the socioeconomic statuses including educational levels and incomes were added to the model, those socioeconomic factors showed significant and robust impacts on healthy aging, whereas the impacts of marital status and location were found to be less significant. Furthermore, the health-related and social behaviors, including drinking behaviors ($\beta = 0.201$, $P < 0.001$) and social participation ($\beta = 0.143$, $P < 0.001$), were also found to be the significant in the full model (Table 5).

Discussion

In the present study, four health profiles were identified among the aging population observed in the TLSA. The combined effects of the physical functioning, cognitive and emotional health, and comorbidities showed the health heterogeneities of older adults and changes of their health profiles. Apart from health deteriorating with age and sex disparities, educational and economic status, health behaviors, and social participation at the individual level were found to be robust factors in predicting healthy aging. In considering what factors impact healthy aging, it would be both useful and critical for policy makers to understand the compositions of health profiles and the influencing factors in view of a life-course perspective. Some points indicated by the results require further discussion.

With complex chronic conditions, diseases and functional disabilities among older adults, it is critical that all health complaints, both physical and psychological (such as depression and worsening cognitive abilities) should be taken into consideration.[20] By using a person-centered approach, we took multiple observed health indicators into account to describe health heterogeneity more comprehensively, and their subsequent changes provide information regarding the composition of older people's health profiles and an objective classification on healthy aging.

It was not surprising that the composition of the health profiles became negative with increasing age. However, the experience of aging is heterogeneous, even from the biomedicine perspective of aging, it subsists and perpetuates a whole series of structural, interpersonal and symbolic imbalances.[21] With regard to the oldest-old cohort in the present study, estimating their care needs from a macro viewpoint, especially with the increasing probabilities of ADL difficulties and vulnerable positions, will be critical in policy making. It has also been reflected by the definition of health emphasized by the WHO, which

Table 3 Distributions and conditional probabilities of the health indicators for the various health profiles

$n = 11145$	Sample proportion	Class 1 $n = 1139$	Class 2 $n = 1590$	Class 3 $n = 4310$	Class 4 $n = 4106$
Hypertension	0.364	0.449	0.482	0.423	0.231
Diabetes	0.136	0.224	0.200	0.153	0.068
Renal disease	0.083	0.110	0.134	0.106	0.032
Heart disease	0.221	0.268	0.313	0.293	0.097
Stroke	0.080	0.334	0.143	0.051	0.014
Respiratory disease	0.144	0.204	0.183	0.182	0.072
Joint and musculoskeletal problems	0.216	0.235	0.326	0.280	0.099
Cataracts	0.343	0.402	0.478	0.405	0.206
Gastric disease	0.169	0.168	0.229	0.214	0.098
ADL difficulties					
3–4 activities	0.025	0.100	0.093	0.000	0.000
5–6 activities	0.076	0.582	0.106	0.000	0.000
IADL difficulties					
3–4 activities	0.139	0.000	0.744	0.058	0.005
5 or more activities	0.106	1.000	0.000	0.010	0.001
Functional limits (upper)	0.495	0.986	0.967	0.598	0.055
Functional limits (lower)	0.662	0.997	1.000	0.897	0.190
Depression	0.301	0.763	0.578	0.260	0.098
Sensory (hearing) problems	0.178	0.438	0.314	0.150	0.078
Sensory (vision) problems	0.239	0.546	0.463	0.212	0.087
Self-rated health (bad)	0.355	0.752	0.690	0.391	0.067
Cognition impairments	0.287	0.878	0.539	0.197	0.109

Adjusted Bayesian information criteria 187 184.154, entropy 0.80, likelihood ratio test 1780.788, $P < 0.0001$. Condition number 0.521E-06. The 11 145 person-waves were analyzed by using latent class analysis, and four health classes were identified matching a best model fit. Each health class was named as follows: Class 1: Frail – worst health status with high comorbidities and physical/cognitive impairments; class 2: Functional impairment – worse health status with high comorbidities and functional limitations; class 3: High Comorbidity – with high probabilities for various diseases, but no difficulties in activities of daily living (ADL); and class 4: Relatively Healthy – with relatively healthy status and no difficulties in ADL and instrumental ADL (IADL).

makes the relationship between health and aging explicit, with a particular emphasis on the influence of health on quality of life and society as a whole.[22]

Our findings detail the health heterogeneity older adults, showing their differences and the fact that sociodemographic characteristics have had a strong influence on healthy aging over time. This is consistent with a cross-national study that found that age, sex, and socioeconomic status are significantly and highly associated with individuals' odds of successful aging,[23] with successful aging being defined strictly as "having no major disease, no activity of daily living (ADL) disability, no more than one difficulty with seven measures of physical functioning, obtaining a median or higher score on tests of cognitive functioning, and being actively engaged" (as defined by McLaughlin *et al.*).[24]

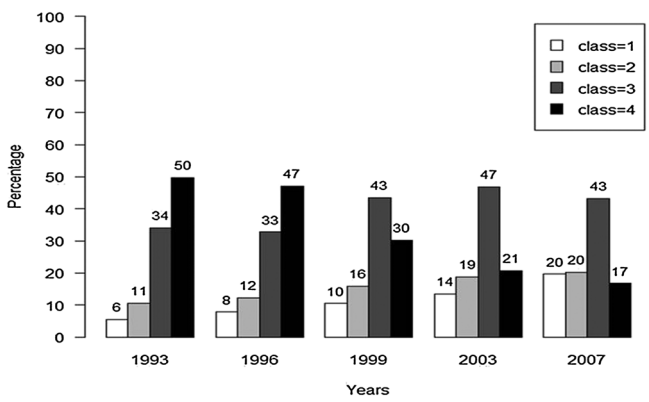

Figure 1 The percentage changes for each health profile over the five waves. It helps with the description of the different health profiles changes over time among older adults. For example, the percentage of those in class 4 (relatively healthy group) has decreased from 50% in 1993 to 17% in 2007.

Table 4 Transition probability matrix for health profiles of older adults in Taiwan between 1993 and 2007

Health profiles in 1993 ($n = 3144$)		Health profiles' probability distribution in 1996					
Class	Size	Died	Class 1	Class 2	Class 3	Class 4	NA
Class 1	184 (5.85%[†])	90 (48.9%[‡])	52 (28.3%)	13 (7.1%)	10 (5.4%)	1 (0.5%)	18 (9.8%)
Class 2	335 (10.65%)	78 (23.3%)	65 (19.4%)	90 (26.9%)	57 (17%)	13 (3.9%)	32 (9.6%)
Class 3	1067 (33.9 %)	124 (11.6%)	64 (6.0%)	148 (13.9%)	415 (38.9%)	223 (20.9%)	93 (8.7%)
Class 4	1558 (49.56%)	78 (5.0%)	21 (1.3%)	57 (3.7%)	342 (22%)	945 (60.7%)	115 (7.4%)
Health profiles in 1996($n = 2516$)		Health profiles' probability distribution in 1999					
Class 1	202 (8.03%)	70 (34.7%)	81 (40.1%)	30 (14.9%)	4 (2.0%)	1 (0.5%)	16 (7.9%)
Class 2	308 (12.24%)	65 (21.1%)	65 (21.1%)	87 (28.2%)	69 (22.4%)	7 (2.3%)	15 (4.9%)
Class 3	824 (32.75%)	106 (12.9%)	46 (5.6%)	146 (17.7%)	373 (45.3%)	93 (11.3%)	60 (7.3%)
Class 4	1182 (46.98%)	77 (6.5%)	18 (1.5%)	60 (5.1%)	444 (37.6%)	520 (44.0%)	63 (5.3%)
Health profiles in 1999($n = 2155$)		Health profiles' probability distribution in 2003					
Class 1	227 (10.53%)	135 (59.5%)	47 (20.7%)	15 (6.6%)	10 (4.4%)	0 (0.0%)	20 (8.8%)
Class 2	343 (15.92%)	110 (32.1%)	62 (18.1%)	94 (27.4%)	42 (12.2%)	0 (0.0%)	35 (10.2%)
Class 3	935 (43.39%)	144 (15.4%)	83 (8.9%)	141 (15.1%)	423 (45.2%)	81 (8.7%)	63 (6.7%)
Class 4	650 (30.16%)	68 (10.5%)	18 (2.8%)	40 (6.2%)	245 (37.7%)	242 (37.2%)	37 (5.7%)
Health profiles in 2003($n = 1615$)		Health profiles' probability distribution in 2007					
Class 1	220 (13.62%)	119 (54.1%)	67 (30.5%)	17 (7.7%)	2 (0.9%)	0 (0.0%)	15 (6.8%)
Class 2	303 (18.76%)	91 (30.0%)	81 (26.7%)	71 (23.4%)	36 (11.9%)	5 (1.7%)	19 (6.3%)
Class 3	757 (46.87%)	131 (17.3%)	52 (6.9%)	128 (16.9%)	328 (43.3%)	56 (7.4%)	62 (8.2%)
Class 4	335 (20.74%)	38 (11.3%)	14 (4.2%)	14 (4.2%)	126 (37.6%)	126 (37.6%)	17 (5.1%)

Source: Taiwan Longitudinal Study on Aging 1993–2007. There were 3144 persons with valid death registration among 3155 respondents in 1993 baseline. [†] 5.85 %$5.85 \fallingdotseq (184/3144) \times 100$(class 1 size / total class size) *100% = 184/(184+335+1067+1558) * 100%. [‡] 48.9%$48.9 \fallingdotseq (90/184) \times 100$ class 1 died/ class 1 size = (90/184)*100%. For each row, percentages in each cell add up to 100%. NA, data is not available due to dropout or missing.

Regarding the concept of "Healthy Aging," both the WHO (2002) and SNIPH (2007) pay greater attention to improving the situation of older adults against a wide range of objectives relating to their individual well-being.[7,8] The maintenance of personal control over one's life as physical health gradually declines is a key ingredient to policy.[8] In the present study, apart from the personal characteristics, such as age, sex and religion, the socioeconomic statuses, the health and social behaviors at the individual level also showed critical roles in terms of their influences on healthy aging. Regular social participation was found in this research to be a robust factor in terms of protecting a person from deteriorations in health. That means that the healthy behaviors and social relationships appear to be influential factors of health status that might compensate for personal factors, such as marital status. This is also evident in a previous study suggesting that expansive health and social behaviors – specifically, older adults that extend beyond their family relationships – showed key protective factors of better general health.[25] The results of the Hale project also show that women living in southern Europe have more social contacts and lower total morbidity than those in northern Europe, and the same was found for men either living with a partner or with other people.[26]

Healthy aging could be more meaningful if it is regarded relatively in a life-course perspective among older adults.[7] In addition, it reflects our later life in a real world. We could not expect everyone to be aging perfectly; however, to maintain good health and therefore relatively healthy aging, which is meaningful both for the individuals and the society, should be the goal in policy making. In the present study, the causal relationships between these characteristics were shown to be important not only for identifying the high-risk groups, but also for providing a reflection of the society in terms of how to overcome barriers and facilitate better social and environment contextual factors to help with healthy aging. Health heterogeneity and needs across individuals must be taken into account. As we know that these factors do have impacts on and predict healthy aging, the ways in which society can intervene to affect the structural contexts of aging need to be examined, rather than simply shifting responsibility back to individuals alone. As emphasized by the Organization for Economic Cooperation and Development, population-wide healthy aging requires focusing on health inequalities and the underlying socioeconomic factors. Healthy aging will also depend on the institutional and social support structures that permit the older adults to find their footing in society.[27] As Rowe and Kahn have emphasized, changes in major social institutions (including the family, education, civic engagement, work and retirement) should also be critical factors that shape how or even whether older adults achieve successful aging.[28]

Table 5 Factors predicting health changes over 14 years (generalized estimating equation model)

	Model 1 Estimate	SE	*P*-value	Model 2 Estimate	SE	*P*-value	Model 3 Estimate	SE	*P*-value
Age	–0.052	0.002	<0.001***	–0.044	0.002	<0.001***	–0.042	0.002	<0.001***
Sex (ref. male)									
Female	–0.443	0.027	<0.001***	–0.303	0.029	<0.001***	–0.218	0.033	<0.001***
Wave(ref. 1993)									
1996	–0.171	0.016	<0.001***	–0.172	0.016	<0.001***	–0.174	0.016	<0.001***
1999	–0.475	0.017	<0.001***	–0.475	0.017	<0.001***	–0.477	0.017	<0.001***
2003	–0.765	0.022	<0.001***	–0.77	0.022	<0.001***	–0.775	0.022	<0.001***
2007	–1.034	0.027	<0.001***	–1.04	0.027	<0.001***	–1.046	0.027	<0.001***
Marital status (ref. married)									
Not married	–0.071	0.029	0.014*	–0.017	0.028	0.557	–0.014	0.028	0.624
Religion (ref. with)									
Without	–0.288	0.043	<0.001***	–0.319	0.042	<0.001***	–0.297	0.041	<0.001***
Locations (ref. city)									
Rural	–0.11	0.025	<0.001***	–0.015	0.026	0.577	–0.028	0.026	0.291
Education (ref. illiterate)									
Elementary school				0.193	0.032	<0.001***	0.18	0.032	<0.001***
High school				0.306	0.04	<0.001***	0.29	0.04	<0.001***
Incomes (ref. <60 000 NTD)									
60 000–120 000				0.157	0.036	<0.001***	0.147	0.035	<0.001***
120 000–240 000				0.227	0.034	<0.001***	0.215	0.033	<0.001***
>240 000				0.308	0.039	<0.001***	0.284	0.039	<0.001***
Smoking (ref. no)									
Yes							0.042	0.03	0.163
Alcohol (ref. no)									
Yes							0.201	0.03	<0.001***
Social participation (ref. no)									
Yes							0.143	0.025	<0.001***
qLik	–3782.5			–3652.2			–3615		
QIC	–3649.7			–3990.1			–4092.9		

n = 3118. Sample characteristics based on 1993 Taiwan Longitudinal Study on Aging. QIC, quasilikelihood under the independence model criterion; qLIK, quasilikelihood.

Hank also called for "policy interventions supporting individuals' opportunities for successful aging."[23] Therefore, the policy makers who are seeking to promote healthy aging would do well to foster the structural factors also to support activities at the individual level for healthy aging, including physical and social activities to promote positive health, and those to maintain the socioeconomic status of older adults in later life.

In the present study, the strength of our measures on health captured a variety of health dimensions, such as comorbidities, functional status, cognitive health, emotional health, self-rated health and mobility, all of which were shown by a variety of health indicators that might not change in the same direction over time when measuring the health status of older adults. It was useful to follow up on the health changes of the sample cohort more objectively in considering all the possible health indicators by using the same categorizing standard. Another advantage was the opportunity to analyze the factors influencing healthy aging among an oldest sample cohort in Taiwan that came from the longitudinal follow-up data of a representative national survey of older people.

In contrast, the TLSA is a nationally representative survey of Taiwanese older adults, with the initial respondents, an oldest sample cohort who were given the group name "cohort B," having been selected from the population aged 60 years and older in 1989. One limitation was that the health indicators in the study were restricted to those available in the TLSA surveys that had consistent questions in each wave. Incorporating more comprehensive health indicators might classify health profiles more accurately and increase the explanatory power of future research. Second, the TLSA survey and its follow ups have primarily been designed to provide a clear understanding of the health and living statuses of the respondents, so there were no questions regarding structural factors, such as the provision of services or information about physical/social environments available, apart from the variable of urbanization. Incorporating or combining structural information is necessary in the future. Third, we lost some elderly participants due to death and dropping out of the study during the 14 years of follow up, so the results should not be generalized without caution.

In considering what factors impact healthy aging, we suggest that a person-centered approach would be both useful and critical for policy makers to understand the compositions of health profiles, their heterogeneity of needs and the influencing factors in view of a life-course perspective. In viewing the influencing factors and a sense of management to healthy aging, the present study suggests a variety of implications for how policy interventions might support the likelihood of older adults nationwide achieving healthy aging.

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Disclosure statement

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