THE PARADOX OF AGING AND HEALTH-RELATED QUALITY OF LIFE: RESULTS FROM THE HEALTHY AGING LONGITUDINAL STUDY IN TAIWAN (BASELINE)

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ABSTRACT

The "paradox of aging" is a term coined by researchers to label the counterintuitive phenomenon that older adults maintain high levels of subjective well-being in spite of considerable decrements in objective health status. The present study extended the literature on this phenomenon to Asian contexts by examining age trajectories of health-related quality of life (HRQoL) and objective health in a large and nationally representative sample of Taiwanese participants (n = 3,856) aged 55 and older. We found divergent cross-sectional age trajectories for objective health (sensory and physical functioning) as well physical (PCS) and mental components (MCS) of HRQoL (as assessed with the 12-item Short-Form Health Survey; SF-12). Both PCS and objective health were negatively associated with age, but this effect was weaker for PCS. MCS, in turn, showed a positive association with chronological age. Consistent with prior research on the paradox of aging, the association between objective health and PCS became weaker with age. For MCS, associations with objective health did not vary by age, and controlling for objective health strengthened the observed positive association between MCS and age. These findings add to prior evidence indicating that—in spite of objective health decrements—subjective HRQoL is maintained in later life. However, these patterns appear to vary for mental and physical components of HRQoL, and future research is needed to explore the underlying mechanisms.

This thesis is dedicated to all participants and their family in the Healthy Aging Longitudinal Study in Taiwan

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LIST OF ABBREVIATIONS

HALST: healthy aging longitudinal study in Taiwan

HRQoL: health-related quality of life

SF-12: the 12-item Short Form Health Survey for the Medical Outcomes Study (MOS)

PCS: physical component score of SF-12

MCS: mental component score of SF-12

GDP: gross domestic product

LOESS: locally weighted scatter-plot smoother

OR: odds ratio

SAS: statistical Analysis system

SD: standard deviations

CI: confidence intervals

CHAPTER 1

INTRODUCTION

Health-related quality of life (HRQoL) is a multidimensional concept which is increasingly recognized as a key indicator of well-being across the life-span (WHOQoL Group, 1995). While it is intuitive to assume that age-related declines in health and functioning are associated with a lower perception of quality of life, empirical studies have documented stable, if not increasing, subjective well-being across adulthood (Jeste et al., 2013; George & Landerman, 1984; Kunzmann, Little, & Smith, 2000; Robnett, 2002), except among people approaching the period of terminal decline (Gerstorf et al., 2010).

The "paradox of well-being" is a term coined by researchers to label this counterintuitive phenomenon of an apparent decoupling between objective health and subjective quality of life as one gets older (Mroczek & Kolarz, 1998). Subsequent research has begun to unravel this paradox by showing that age-related shifts in material and psychosocial resources along with age-related changes in coping styles can account for high levels of HRQoL among older adults (Siedlecki, Tucker-Drob, Oishi, & Salthouse, 2008). However, even though the phenomenon has been documented across a range of cross-sectional and longitudinal studies (Carstensen, 1995; Diener & Suh, 1998; Jivraj, Nazron, Vanhoutte, & Chandola, 2014; Kunzmann, Little, & Smith, 2000; Netuveli, Wiggins, Higgins, Montgomery, & Blane, 2006; Zaninotto, Falaschetti & Sacker, 2009), much of this work has been conducted in Western and highly industrialized societies and it is not clear to what extent such patterns are universal (Spini, Jopp, Pin, & Stringhini, 2016).

The present study extends the literature on the “paradox of aging” to Asian contexts by examining age trajectories of HRQoL and objective health in a large and nationally representative sample of Taiwanese participants aged 55 and older. To situate our project within

the prior literature, we begin with a brief definition of HRQoL and a review of prior work on age-trajectories in objective and subjective aspects of health and related variables, with particular emphasis on divergent trajectories in objective and subjective aspects of health. We then turn to theoretical frameworks explaining late life stability in HRQoL. Next, we consider the limited literature on cross-cultural differences in such mechanisms, and finally turn to the rationale and specific hypotheses for the present study.

CHAPTER 2

LITERATURE REVIEW

Health-related quality of life

Health-related quality of life (HRQoL) is a multidimensional concept. It incorporates the domains of health-related subjective well-being[1] and physical, social, and psychological functioning (Bond & Corner, 2004; O'Connor, 2004; Patrick, Bush, & Chen, 1973; Revicki, 1989; WHOQoL Group, 1995). The Short Form 36 (SF-36) and the abbreviated Short Form 12 (SF-12) are among the most popular surveys for assessing health-related quality of life worldwide (Brazier et al., 1992). They each comprise two summary measures, a physical component summary (PCS) and a mental component summary (MCS). Using SF-36 or SF12, previous studies have found that HRQoL is associated with a variety of health-related outcomes, including future hospitalizations and mortality in community-dwelling seniors (e.g., Dorr et al., 2006). Therefore, researchers have argued that it constitutes a key target for health services and interventions in the new millennium (Bowling, 2005; Hennessy, Moriarty, Zack, Scherr, & Brackbill, 1994).

Age trajectories of quality of life

Self-reported quality of life usually follows a U-shaped or curvilinear relationship over the course of the life cycle (Diener, Suh, Lucas, & Smith, 1999; Frijters & Beatton, 2012). Individuals' well-being seems to remain relatively stable after the 18th birthday, with the lowest

[1] The present study recognizes the similarities and differences among the concepts of quality of life, subjective well-being, life satisfaction, and happiness, as well as the variations in how previous research conceptualized them. Thus, the literature search centered on, but was not limited to, health-related quality of life.

points reported between mid-30s and early 50s in the US, Canada, UK, most of the West European countries, Australia, and New Zealand ((Blanchflower & Oswald, 2008; Clark & Oswald, 1994, 2006; Deaton, 2008; Frijters & Beatton, 2012; Steptoe, Deaton, & Stone, 2015). The results were found to be fairly robust in various domains of quality of life (McAdams, Lucas, & Donnellan, 2012), for men and women (e.g., Blanchflower & Oswald, 2008), by raw or covariates-adjusted data (e.g. Frijters & Beatton, 2012), as well as cross-sectional and longitudinal analyses (Clark & Oswald, 2006).

The reasons underlying the dip in subjective well-being in midlife are not clear. One possible explanation for the lower quality of life in midlife is informed by Sheikh and Strachan's (2004) two-state model of disease, in which aging trajectories are influenced by the rates at which health-related resources are accumulated and progressively lost over time (Sheikh & Strachan, 2004). Midlife is the time people usually reach the peak of their career, familial, and economic responsibilities at the expense of well-being. Deteriorating health, along with accumulated life stressors and competing demands from work and family, can be particularly difficult and detrimental to well-being in middle age (Case & Deaton, 2015; Shields & Wooden, 2003).

However, what interested gerontological researchers, and was initially considered a mystery, was the robust upturn of subjective well-being found later in life when health-related resources (such as health, functioning, and financial sources) are progressively lost and stressful life events (such as death of spouse, relatives and friends) occur more frequently over time. The seemingly paradoxical finding of an upturn in subjective well-being in older age was supported in many longitudinal aging studies around the world. For example, using 22 waves of data from the Veterans Affairs Normative Ageing Study with males between 40 and 85 years old, Mroczek

and Spiro (2005) found a peak of subjective well-being, defined as positive affect, at around age 65. Thus, consistent with the U-Shaped relation mentioned previously, the highest well-being scores are reached in late life (Mroczek & Spiro, 2005). Similarly, when potential covariates (i.e., sex, education, income, driving ability, perceived financial inadequacy, long-term illness, Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs), closeness of relationships with friend and family, living in a good neighborhood, depression, etc.) were adjusted, researchers in the English Longitudinal Study of Ageing observed that the quality of life increased from age 50 onwards, peaked at age 68, and gradually declined to the same level of age 50 by age 86 (Carstensen, 1995; Lawton, Kleban, & Dean, 1993; Netuveli, Wiggins, Hildon, Montgomery, & Blane, 2006). Longitudinal analyses of the same dataset also echoed such findings: many of the older adults consistently reported the same level, if not improved, quality of life and well-being up to the age of 75 (Jivraj, Nazroo, Vanhoutte, & Chandola, 2014). This consistent findings that subjective well-being is maintained or even improved in late life in spite of so many well-documented losses that occur with aging, has also been labeled the "paradox of well-being" (Mroczek & Kolarz, 1998).

Life course perspectives (e.g., Bengtson, Elder, & Putney, 2005) explain this phenomenon by arguing that although losses in objective health and socioeconomic status are obvious with aging, the effects of considerable reserves and continued gains in psychosocial functioning on quality of life are also noticeable. The latter were found to compensate for objective losses in health and socioeconomic status, even in the very last phase of life (Kunzmann, Little, & Smith, 2000). To understand the specific psychosocial mechanisms underlying the paradox of well-being, we turned to empirical findings regarding relevant covariates to capture the challenges and resources typically encountered in later life — what is

lost (e.g., income, health, or physical functioning), what is preserved (e.g., social relationships), what is gained (e.g., maturity and emotion regulation skills), as well as the contexts in which these losses and gains interact with one another to lead to inter- and intra-personal differences in quality of life.

HRQoL covariates in late life

Across all of the existing research, a core set of age-related variables were consistently found to be associated with HRQoL (Chen, 2001; Guillemin, Bombardier, & Beaton, 1993; Kaplan, Anderson, & Wingard, 1991; Kunzmann et al., 2000; Lam, Tse, & Gandek, 2005; Li et al., 2014; W. Sun et al., 2015; Tajvar, Arab, & Montazeri, 2008; Wilson & Cleary, 1995). In general, these variables reflected individuals' command over resources in the form of money, behavioral competences, social relationships, as well as objective mental and physical health over time. Depending on which theoretical approaches informed the research (e.g., intra-personal or socio-normative), these studies varied in definition of outcome measures (e.g., successful aging, life satisfaction, subjective well-being, happiness, positive and negative affect, quality of life, or health-related quality of life), study designs (e.g., cross-sectional vs longitudinal studies), research methods (e.g., qualitative vs quantitative), populations of interest (e.g., institutionalized or community-dwelling older adults), and cultural contexts.

First, demographics and socioeconomic status (SES) such as income (George, 1992; Harding-hidore, Stock, Okun, & Witter, 1985), marital status (Glenn & Weaver, 1979; Gove, Style, & Hughes, 1990), and co-residence with spouse and adult children (Hughes & Waite, 2002; Lawton, Kleban, & diCarlo, 1984; Zimmerman & Sloane, 2007) typically represent resources that protect individuals from the negative impacts of adverse life events in late life. However, the

specific benefits and detriments of these characteristics for HRQoL were inconsistent (Lund, Due, Modvig, Damsgaard, & Andersen, 2002; Zunzunegui, Béland, & Otero, 2001) and varied as a function of gender (e.g., Harding-hidore et al., 1985) and cultural contexts (Diener, Gohm, Suh, & Oishi, 2000). In addition, previous studies suggested that combined sociodemographic variables, including education, income, gender and marital status, could only account for 8 to 15% of the variance in explaining subjective well-being in general population (Diener et al., 1999). Meta-analyses showed that SES accounted for an even smaller amount of variations (2.2 to 3.2%) in subjective well-being among older adults aged 55 and above (Pinquart & Sörensen, 2000).

Second, research indicated that psychosocial factors may have substantial influence on quality of life in older adults beyond physical functioning and health status (e.g, Kim, Bae, Kwon, & Cho, 2010). Social relationships were found to not only promote subjective well-being when one gets older (Barrera, 1986; Bowling, 2005; Diener, Oishi, & Lucas, 2003), but they also explained over 20% of the variance in life satisfaction in old age (Dumitrache, Rubio, & Rubio-Herrera, 2017). In addition, they were found to be important moderators of the impact of stressful life events (e.g., death of a spouse; (Hsu & Tung, 2010) and objective health decrements on subjective well-being (Dumitrache et al., 2017).

Third, poor sensory and physical functioning are not only prevalent among older adults, but they were found to have long-term, negative impact on HRQoL in community-dwelling older adults (Carabellese et al., 1993; Klein, Klein, Lee, Cruickshanks, & Chappell, 2001). In a population-based study with adults aged 53 to 94, Fischer et al. (2009) found that hearing loss was associated with a lower mental component summary score (MCS) while vision loss was

negatively associated with both component scores (i.e., PCS and MCS). The lowest scores were found among participants who had dual (vision and hearing) impairments (Fischer et al., 2009).

Finally, regarding physical functioning among older adults aged 70 and above, more favorable chair stand scores and walk times were associated with higher HRQoL (Groessl et al., 2007). More specifically, Hall and colleagues (2011) found an association between men's upper body physical functioning (i.e., hand grip strength) and the mental component summary score (MCS), as well as men's lower body physical functioning (i.e., a timed walk test and chair stand tests) and the lower physical component summary score (PCS) of the SF-12 (Hall, Chiu, Williams, Clark, & Araujo, 2011).

In summary, HRQoL shows robust associations with demographics, social embeddedness, as well as physical and sensory functioning. However, the strength of these associations is not uniform across the life-span, especially with regard to physical health.

The decoupling of objective health and HRQoL in late life

Although most studies suggest that a person's health is strongly associated with quality of life (e.g., Wiggins, Higgs, Hyde, & Blane, 2004), especially for those suffering from significant physical and cognitive impairments (Hsiao et al., 2016; Reed & Carstensen, 2012) and approaching terminal decline (e.g., Gerstorf et al., 2010; Zaninotto, Falaschetti, & Sacker, 2009), the accumulated literature has also shown that objective health is not sufficient to explain subjective evaluations of well-being (Diener & Suh, 1997; Jeste et al., 2013; Kunzmann et al., 2000; Robnett, 2002). Besides, while the objective evaluation of health status is critical for defining one's degree of health, it is the personal interpretation by each person that translates

objective components of health into subjective quality of life (Testa & Simonson, 1996). Thus, people with the same objective health status may express different health-related quality of life.

The consistent reports of stable or increased levels of subjective well-being among older adults suggest that the correspondence between objective health and subjective health and functioning weakens with age (Idler, 1993). This increasing decoupling of subjective and objective health getting wider with age in healthy aging is at the core of the paradox of aging, and a range of theoretical explanations for this striking phenomenon have been advanced.

Theoretical frameworks behind the paradox of aging

Heredity and personality

The loosened relationship between objective and subjective dimensions of quality of life in late life can be partially explained by set point theory (Brickman & Campbell, 1971). This theory argues that individuals are born with a predisposition, rooted in the genetic underpinnings of personality that largely determines their subjective well-being. Even when facing life-changing events, these changes only have temporary effects on the individual's subjective well-being. The term *hedonic adaptation*, defined as "the process by which individuals return to baseline levels of happiness following a change in life circumstances" (Lucas, 2007, p. 75), describes this return to the original, biologically determined level of well-being despite previous adversities with aging.

Within this context, personality appears to be one of the strongest and consistent predictors of quality of life, especially when quality of life was operationalized as positive and negative affect. A number of studies on personality have also revealed that, as personality matures, there is an age-related increase in Agreeableness and Conscientiousness but decrease in

Neuroticism over time (e.g., McCrae, Costa, & Martin, 2005; Roberts & Mroczek, 2008) that may account for higher levels of subjective well-being in late life.

However, studies found that heritability only accounted for, at best, 50% to 80% of the variance in quality of life (e.g., Lykken & Tellegen, 1996). Diener and colleagues also argued that while a predispositional point of view is useful, it provides an incomplete explanation of the dynamic processes underlying of subjective well-being (Diener, Suh, Lucas, & Smith, 1999), and trends of age-related improvements in subjective well-being at the population level. Besides, focusing on heredity leaves little room for policy and programs to improve the level of quality of life in any phase of life (Diener et al., 1999). Process-oriented theoretical frameworks focusing on appraisal, motivation, and active self-regulation provide a complimentary perspective on subjective well-being in late life.

Appraisal and comparative evaluation

In part, the paradox of well-being may reflect positive cognitive biases such as self-presentation bias or social desirability which were found to increase with age in some studies (Pinquart & Sörensen, 2000). For instance, older adults may conform more to social norms and try to present themselves in a more favorable way as an attempt to preserve their social image (Dijkstra, Smit, & Comijs, 2001; Soubelet & Salthouse, 2011). However, this proposition is controversial since some studies suggest that the influence of social desirability on subjective well-being in late adulthood is overestimated (Phillips, Henry, Hosie, & Milne, 2006). Empirical results showed that only 5% of life satisfaction can explained by self-rated social desirability effects among older adults aged 65 and above (e.g., Fastame, Hitchcott, & Penna, 2017).

An alternative explanation focuses on targeted social comparison processes that may help to protect older people's self-perceptions from the negative impacts of aging (e.g., Cheng, Fung, & Chan, 2007). Specifically, rather than comparing themselves with the population as a whole, older adults may compare themselves with people their own age who are doing worse than they are. Consistent with this view, researchers have found that individuals aged 65 and above, when asked to compare themselves with same sex and age peers, gave higher ratings of their health than those who did not receive comparison instructions (Baron-Epel & Kaplan, 2001). Previous research also found that social comparison serves a self-enhancing purpose over the life course (Heckhausen & Krueger, 1993) and can be adaptive in preserving subjective well-being when facing health-related problems in old age (Heidrich & Ryff, 1993).

Some researchers also reported that older adults engaged in targeted temporal comparisons (e.g., Wilson & Ross, 2000) which allowed them to enhance present self-representations by downgrading past representations. For example, Chen (2001) explained the upturn of life satisfaction among Taiwanese older adults beyond age 70 by the fact that the cohorts were born between or before two World Wars. At the time of the survey, when they reached their 70s, the cohort had survived post-war hardship in young adulthood, and contributed to and experienced better life with Taiwan's fast economic growth in late 1970s. It is possible that they would hold a more positive impression of the second half of their lives because of these historical circumstances (Chen, 2001).

Motivation

Beyond age differences in appraisal and comparative evaluation, older adults may also restructure their goal priorities to ensure that they are achievable in spite of health-related

constraints and optimally leverage remaining resources. At the broadest level, the meta-theory of selection, optimization and compensation (SOC, M. M. Baltes & Carstensen, 1996; P. B. Baltes & Baltes, 1993; Marsiske, Lang, Baltes, & Baltes, 1995) emphasizes the psychosocial resources of an individual (e.g., life experience, mature emotionality), accumulated through the life course, to maintain continued well-being in the face of age-related losses. By intentionally selecting activities that are most salient to one's life (selection; e.g., maintain everyday functioning), maximizing one's resources (optimization; e.g., objective health and functioning), and using alternatives (compensation; e.g., social supports), older adults can also maintain stable, if not increased, quality of life compared to that of younger ages.

More specifically, with regard to self-related goals, the goal discrepancy perspective (Campbell, Converse, & Rodgers, 1976) proposes that well-being is lower when the degree of discrepancies between goal (inspirational status) and current state is higher. It has been suggested that, by downregulating such discrepancies by adjusting their ideals, older adults may be able to maintain emotional well-being even under adverse circumstances (Higgins, Grant, & Shah, 2003). In a study of young, middle and older age adults evaluating possible selves, Ryff (1991) found not only that ideal-self-ratings were consistently lower among older adults compared to middle and young adults; older adults also reported the smallest ideal-versus-actual-self discrepancies by reporting stable levels of past and present psychological well-being, as well as expecting losses, instead of gains, in most aspects of well-being in the future. Thus, greater consistency between ideal and actual selves may account for older adults higher scores in subjective well-being, especially in the affective domain (Ryff, 1991).

With regard to specific goal types, socioemotional selectivity theory (SST; Carstensen, 2006; Carstensen, Isaacowitz, & Charles, 1999) states that when people get older, there is a

motivational shift in values and preferences due to the limited time ahead of them. Such a motivational shift makes older adults become increasingly and adaptively selective in investing resources (energy, time, attention etc.) in goals that contribute to emotionally meaningful activities in the present moment (e.g., positive experiences, close social relationships) rather than goals that are oriented towards a distant future (e.g., information seeking).

In summary, research on age differences in motivational priorities indicates a strategic shift towards achievable, emotionally meaningful goals that can be realized in spite of age-related limitations in physical health. Moreover, age-related trends in self-regulation indicate that older adults are well-equipped to achieve such goals.

Self-regulation

In general, the ability to self-regulate is well-maintained with age including adjustment to environmental circumstances (Kessler & Staudinger, 2009), as well as emotion regulation (e.g., Carstensen, Fung, & Charles, 2003; Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Labouvie-Vief, Diehl, Jain, & Zhang, 2007). At the broadest level, Schulz and Heckhausen's (1996) life course theory of control differentiates between primary and secondary processes — primary control pertains to active attempts to change the external environment, whereas secondary control pertains to adjusting one's internal responses (Schulz & Heckhausen, 1996). With age, there appears to be a general shift from primary to secondary control strategies. Moreover, compensatory primary control recruits external resources to pursue goals that one can no longer accomplish oneself. Compensatory secondary control, in turn, serves to buffer the negative effects of losses of one's primary control, and includes the processes of disengagement from previous goals and engagement of alternative goals. Consistent with this view, perceived

control over desirable and undesirable outcomes was shown to be related to differences in subjective well-being in older age (Kunzmann et al., 2000).

In addition to broad shifts in control strategies, age is associated with proactive changes in the processing of emotional stimuli and a restructuring of social networks. Specifically, the literature has identified an age-related "positivity effect" such that older adults selectively prioritize positive over negative information in cognitive processing including attention, appraisal, and memory (Charles, Mather, & Carstensen, 2003; Mather & Carstensen, 2003; Reed & Carstensen, 2012). Moreover, older adults appear to restructure their social networks to meet their changing needs. According to the convoy model of social relations (Antonucci, Ajrouch, & Birditt, 2014; Antonucci & Akiyama, 1987; Kahn & Antonucci, 1980) people are surrounded by a dynamic network of social ties which fluctuates over time in response to life transitions but retains a relatively stable core of close social ties (e.g., close friends, siblings and romantic partners) across adulthood (Kahn & Antonucci, 1980). With age, there appears to be an intentional restructuring of social convoys to reduce peripheral ties and prioritize core relationships that offer a stable source of social engagement and gratification (Lang, 2001).

In combination, psychosocial mechanisms — including stable set points of emotional well-being, appraisal and comparison processes, goal reorganization, and well-preserved self-regulatory strategies — offer potential pathways by which HRQoL may be maintained in spite of health-related challenges in later life. Although the present study was not intended to directly test and compare these theories, they have important implications for selecting relevant covariates. At the same time, it is important to acknowledge that they may not function consistently across different demographic and social groups. According to the value-as-a moderator model (Oishi,

Diener, E., & Lucas, 1999), there is significant individual, situational and cultural variance in predictors of subjective well-being which requires further consideration.

Demographic and cultural factors in the paradox of aging

In line with the value-as-a-moderator model, some researchers have argued that age effects and age-related determinants on HRQoL depend on an individual's perception of their position in life under the given culture and value systems (Diener, Pressman, Hunter, & Delgadillo-Chase, 2017; Grewal, Nazroo, Bajekal, Blane, & Lewis, 2004). Further, differences in economic development and political priorities across societies affect resources and public health infrastructure available for older adults to age well.

For example, in an ecological study using the European Social Survey, Swift et al. (2004) found that gross domestic product (GDP) measured at the country level had a much stronger effect on the subjective well-being of older adults as compared to younger cohorts, and the paradox of well-being could only be observed in the wealthiest countries in Europe (Swift et al., 2014). Similarly, Steptoe et al. (2015) documented that, compared to highly industrialized Western countries, respondents from the former Soviet Union, Eastern Europe and Latin America reported significant declines in well-being in late life. In sub-Saharan Africa in turn, well-being showed significantly lower scores than in Europe and America but there was little change across the life span (Steptoe et al., 2015).

In East Asian contexts, findings on determinants of HRQoL are complicated. One the one hand, associations between age and age-related determinants of subjective well-being were somewhat similar to what was found in the Western countries (e.g., Kim et al., 2010; Lam et al., 2005; Li et al., 2014; Sun, Chen, Johannesson, Kind, & Burström, 2016). In a study conducted in

Hong Kong for example, Lam and colleagues (2005) found that health-related quality of life reflected better physical, psychological and social functioning. Similarly, in a metropolitan population in Taiwan, health-related quality of life was found to be negatively related to older age, frail status, chronic diseases and psychosocial supports (Li et al., 2014).

On the other hand, although the literature generally supported the buffering role of social networks for subjective well-being in late life, Chou and colleagues did not find a moderating effect of social support on the association between SES hardship and subjective well-being among Chinese older adults (Chou & Chi, 2000; Chou, Chi, & Chow, 2004). In addition, the Gallup surveys on life satisfaction done in 1999 and 2010, a period of skyrocketing economic growth in China, failed to find the association between GDP and subjective well-being that had been reported in European and American contexts (Easterlin, Morgan, Switek, & Wang, 2012). In sum, such findings suggest the importance of addressing universality and generalizability of the paradox of aging, an issue that is often overlooked in theories of aging (Norenzayan & Heine, 2005).

Compared to the wealth of literature on age trajectories of subjective well-being in the West, fewer studies in Asian populations are available. After controlling for health-related and SES covariates, researchers found the familiar U-shaped relationship between age and subjective well-being in a Chinese sample aged 15-102 years (Sun et al., 2016), but few studies have specifically tapped into the issue of the paradox of well-being. Among the rare exceptions, studies by Cheng and colleagues in Hong Kong revealed that, compared to younger people, older adults did not rely as much on the extent of physical symptoms to evaluate their health and well-being. Two studies carefully documented the mediating role of social comparison and goal discrepancy in predicting differences in self-rated health (Cheng et al., 2007), life satisfaction, as

well as positive and negative affect (Cheng, 2004) between younger and older adults living in Hong Kong. However, the authors noted that they relied on convenience samples with the older cohort drawn primarily from institutions. Thus, findings are not representative of the general Hong Kong population.

Only one study by Chen (2001) has specifically examined the paradox of well-being with a representative older population in an East Asian context. Using data from the Survey of Health and Living status of the Elderly in Taiwan in 1989 and 1993, Chen revealed that, when correlates of aging effects were controlled, higher life satisfaction (measured by global assessments about life in the past and life in the future) was found among the older birth cohorts (aged 70 and above compared to aged 55). However, it is unknown whether the age trajectories of well-being and the paradox of well-being found in Chen's study twenty years ago would apply to adults currently aging in Taiwan, where significant social, economic, and demographic changes have been observed in the new millennium (e.g., Lin, 2015).

The present study

The present study examined cross-sectional age-trajectories in HRQoL and objective health, as well as the paradox of aging in a Taiwanese older adult sample. It addressed several important limitations of prior work in this area. Most importantly, we extended the scarce literature on the aging paradox in East Asian contexts by utilizing a large, recent, and nationally representative Taiwanese sample. Further, rather than relying on single-item assessments or invalidated measures, we used the well-established SF-12 scale that was shown to be valid across cultures (Lam et al., 2005) and captures the multidimensional nature of HRQoL by assessing both physical (PCS) and mental (MCS) domains of quality of life (e.g., McAdams et al., 2012;

WHOQoL Group, 1995). Moreover, rather than relying on self-report measures of health status which may be subject to social comparison and appraisal processes, we utilized objective, performance-based measures of physical and sensory functioning. Finally, we systematically controlled for a range of relevant covariates including gender, years of education, and cognitive variables.

The first objective was to describe cross-sectional age trajectories of objective health indicators (handgrip strength, physical performance, and visual acuity) and HRQoL (PCS and MCS, respectively). Consistent with the prior literature, we expected to see the strongest age decrements for the objective health, intermediate decrements for PCS, and mild decrements or stability for MCS.

The second objective was to examine the associations between *objective* health indicators and *subjective* HRQoL, and observe variations in this association based on age. According to the literature on the paradox of aging, we expected that, after controlling for demographic and cognitive covariates, the association between age and HRQoL would be reduced when objective health indicators were introduced (mediation model). Meanwhile, consistent with the paradox of aging, we hypothesized that, with advancing age, the predictive value of objective health indicators for HRQoL would be minimized (moderated mediation). In short, we hypothesized that the effect of age on MCS and PCS is mediated by objective health, and the effect of objective health on MCS and PCS is also moderated by age.

CHAPTER 3

METHODS

Data and samples

The data were obtained from the baseline sample of the Healthy Aging Longitudinal Study in Taiwan (HALST; for details, see Hsu et al., 2017). The baseline sample was collected in 2009-2013 from community-dwelling older adults aged 55 and above across Taiwan (n = 5,664; age range = 55.1 to 104.2 years, mean = 69.6 years, SD = 8.3; 52.8% female). We excluded participants (n = 1080; 31.9% of the whole 5,664 cohort sample) who had not completed all variables of interest. Thus, our analyses were based on a total of 3,856 individuals (68.1%). Figure 1 presents a flowchart of the data collection process for the HALST and sample selection for the current study.

Measures

Outcome variables

Health-related quality of life. Health-related quality of life was assessed with the the SF-12v.2 (Ware, Kosinski, Turner-Bowker, & Gandek, 2002). Compared to the longer version (i.e., SF-36), it is better suited for older adults as it is less time-consuming and excludes questions about work (Melville, Lari, Brown, Young, & Gray, 2003). Previous studies have demonstrated the sound psychometric properties (Ware, Kosinski, & Keller, 1996) and cross-cultural compatibility of the SF-12 (Lam et al., 2005), and it is considered suitable for application to Asian populations. The traditional Chinese version of the SF-12v2 was obtained through licensing from QualityMetric (http://www.qualitymetric.com/). The SF-12v.2 includes 2 questions concerning physical functioning (PF), 2 questions on role limitations due to physical

health problems (RP), 1 question on bodily pain (BP), 1 question on general health perceptions (GH), 1 question on vitality (VT), 1 question on social functioning (SF), 2 questions on role limitations due to emotional problems (RE), and 2 questions on psychological distress and well-being (MH). Scoring followed the standard SF-12 algorithms in the user's manual for the SF-12v.2 (Ware, 2007). Yielding two aggregated summary measures: the physical component summary score (PCS) and mental component summary score (MCS).

Predictive variables

Physical functioning. Performance-based mobility was measured by the Short Physical Performance Battery (SPPB; Guralnik et al., 1994, 2000) and hand grip strength. The SPPB contains three components: standing balance, a timed 4-meter walk, and chair stands. The standing balance activity required participants to maintain side-by-side, semi-tandem, and tandem stances for 10 seconds. The 4-meter walk took place twice, and the faster time of the two attempts was used. The chair stands activity asked participants to rise from a chair for five times with arms across their chest. Times for completing the 4 m walk and chair stands were categorized into quintiles, ranging from 0 to 4. Individuals unable to complete the task received a score of 0. The sum of the three components comprised the final SPPB summary score with a possible range from 0 to 12, the higher the score, the better the physical functioning of the lower extremities. For upper limb physical functioning, hand grip strength was used and measured with a North Coast hand dynamometer (North Coast Medical Inc, Gilroy, CA, USA). Participants were measured in a seated position, with shoulder adducted and neutrally rotated and elbow flexed at 90°, and instructed to hold the dynamometer in the hand, and then to squeeze the

dynamometer as hard as they could. Three trials were allowed for each hand in turn. The best performance (unit in kg), was reported and used for the current analysis.

Sensory functioning. We used vision acuity as the indicator for sensory functioning. Participants were first asked if they usually wore eye glasses for distance vision. When the answer was affirmative, vision tests were carried out with glasses in place. Participants were positioned four meters from the E Snellen chart. Average visual acuity was calculated and converted into decimal equivalents. Ranges of vision loss were divided into normal (n >=0.8, score = 2), mild vision loss (0.3=< n <0.8, score = 1), and moderate and severe vision loss (NLP =< n < 0.3, score = 0 (Colenbrander, Lieberman, & Schainholz, 1993). If there was a difference between eyes, the scores for the better eye were reported.

Covariates

Demographic and socioeconomic factors. Demographic and socioeconomic covariates were selected based on findings in literature and included gender (0 = male, 1 = female), education level (0 = none, 1= elementary, 2 = middle school and above), and residence (0 = rural, 1 = urban).

Cognition. The Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975) was used to screen and assess cognitive functioning, including memory, attention, and language. The standard MMSE form is currently used worldwide with minor modifications to adapt to differences in language and cultural conceptualization of the questions. The MMSE has been used extensively in clinical and population-based research to measure cognitive functioning, estimate the severity and progression of cognitive impairment, track the course of cognitive

changes over time and screen for dementia (Cullen, O'Neill, Evans, Coen, & Lawlor, 2007). MMSE scores range from 0 to 30, with higher scores indicating better cognitive functioning.

Analytical plans

The first analysis was descriptive, and categorized participants by demographics, socioeconomics, psychosocial variables, and objective health indictors. The Kruskal-Wallis test or chi-square was used to examine differences in continuous or categorical variables of interest between the included and excluded samples, respectively. After examining the intercorrelations among variables of interest, the second analysis used multiple linear regression models predicting PCS and MCS to test the mediation and moderation hypotheses. The dependent variables were PCS and MCS. Models included: (1) age (tested by linear, quadratic and cubic fashion for best fit); (2) as previous, plus sociodemographic and cognitive covariates, including gender, education level and MMSE; (3) as previous, plus objective health indicators, including disease burden, physical and sensory functioning; (4) as previous, plus interaction terms of age and objective health indicators. All analyses described in the following section were performed using SAS version 9.4 statistical software (SAS Institute Inc., Cary, NC, USA).

CHAPTER 4

RESULTS

Figure 1 presents a flowchart of the data collection process for the HALST and sample selection for the current study. Compared to the final sample, Table 1 shows that those excluded from the analyses were older and had fewer years for education. They were also more likely to suffer from vision loss and have lower scores in MMSE, handgrip, SPPB, and PCS. There were no significant differences in the distributions of gender and MCS score between the included and excluded samples.

Table 1 also presents descriptive statistics for the variables under consideration in the present study. The mean scores for PCS and MCS in our final sample are 47.4 ± 8.5 and 59.4 ± 8.0, respectively. The average age is 69.3 ± 8.2 years (ranging from 55.1 to 104.2 years) and 52% are female. The vast majority of participants (89.2%) had at least elementary school education level when leaving school. The mean handgrip strength is 29.5 ± 10.0 (kg), which falls within the range of normal to strong upper limb strength. The average SPPB score is 10.6 ± 2.4 out of 12. More than half of the present sample (52.4%) had no concern with vision acuity.

We analyzed the zero-order correlations among variables of interest in our model first. As seen in Table 2, age was negatively associated with MMSE (r = -.40, p < .001), handgrip strength (r = -.31, p < .001), SPPB (r = -.41, p < .001), visual acuity (r = -.38, p < .001), and PCS (r = -.25, p < .001), but positively associated with MCS (r = .065, p < .001). Thus, older age was accompanied by more constraints in physical, sensory and cognitive functioning, and lower HRQoL in the physical domain (PCS), whereas HRQoL in the psychosocial domain (MCS) was preserved, if not slightly improved, with age. The divergent cross-sectional age trajectories of PCS and MCS are visualized in Figure 2.

Two further findings in Table 2 deserved mention. First, the zero-order correlation between PCS and MCS is small and negative (r = -.067, p < .001), corresponding to the literature suggesting an independence of subjective well-being in different domains. Second, while both PCS and MCS were significantly correlated with almost all objective health indicators except for sensory functioning, the coefficients of associations with objective health indicators for MCS were relatively small compared to that for PCS.

Multiple regression analysis was used to further examine the age trajectories of PCS and MCS and their associations with the different sets of predictors. Preliminary analyses did not find any evidence for quadratic and cubic age terms (ps >.05). Therefore, subsequent analyses only included a linear age term. Since correlations indicated that the objective health indicators (i.e., handgrip strength, SPPB and vision) were related, we collapsed them into one summary score — objective health status — for the regression analyses predicting PCS and MCS, respectively. The standardized beta coefficients allowed us to directly compare the relative effect size of variables in the models.

Table 3a shows results for PCS. Age was negatively associated with PCS (unstandardized coefficient (B) = -0.26, SE_B = 0.016, p < .001), even after accounting for sociodemographic and cognitive covariates (B = -.019, SE_B = 0.018, p < .001). In Model 3, which added objective health, objective health status was positively associated with PCS (B = 0.37, SE_B = 0.017, p < .001) whereas age effects were reduced to non-significance, suggesting a mediation relationship. Adding objective health status also accounted for an additional 9% of variance in PCS (ΔR^2 = 0.0897, F = 430.17, p < .001). The final model including the interaction term added an additional 1.5% of the variance in PCS (ΔR^2 = 0.0149, F = 72.56, p < .001). The significant interaction between age and objective health status suggested that, the strength of the association

between objective health status on PCS became weaker with advancing age. With one unit increase in age, we saw a corresponding 1.1% decrease in the association between objective health status and PCS (B = 0.011, SE_B = 0.0013, $p < .001$).

Table 3b shows results for MCS. Age was positively associated with MCS (B = 0.063, SE_B = 0.016, $p < .001$). This linear age effect became even stronger after accounting for sociodemographic and cognitive covariates (B = 0.10, SE_B = 0.017, $p < .001$). In Model 3, which added objective health objective health status was positively associated with MCS (B = 0.13, SE_B = 0.018, $p < .001$). Adding objective health status to the model accounted for an additional 1.2% of the variance in MCS score ($\Delta R^2 = 0.012$, F = 47.83, $p < .001$). However, in contrast to the analyses for PCS, the linear effect of age not only remained significant, but doubled in size once objective health was accounted for (B = 0.16, SE_B = 0.019, $p < .001$). In the final model, the interaction term of age*objective health status was not significant. Adding an interaction terms did not account for a significant change in the explained variance in MCS, either. These results suggested that the impact of objective health indicators on MCS did not differ among younger or older age groups. As seen in Model 3, a higher MCS score was found among those with older age (B = 0.16, SE_B = 0.019, $p < .001$), female gender (B = 1.43, SE_B = 0.38, $p < .001$), better cognitive functioning (B = 0.23, SE_B = 0.051, $p < .001$), and higher objective health status (B = 0.13, SE_B = 0.018, $p < .001$).

CHAPTER 5

DISCUSSION

The present study examined cross-sectional age-trajectories in HRQoL and objective health, as well as the paradox of aging in a Taiwanese older adult sample. It extended the scarce literature on the aging paradox in East Asian contexts by utilizing a large, recent, and nationally representative Taiwanese sample. Rather than relying on single-item measurements, we used the well-established SF-12 scale to captures the multidimensional nature of HRQoL. Moreover, we utilized objective, performance-based measures of physical and sensory functioning (rather than self-reported health status which is subject to social comparison and appraisal processes) to examine associations with HRQoL.

Age trajectories of MCS, PCS and objective health in old age

The first objective of the present study was to describe cross-sectional age trajectories of objective health indicators and HRQoL. Consistent with our hypothesis, zero-order correlations showed divergent cross-sectional age trajectories for objective health, as well as PCS and MCS components of HRQoL. For our sample, older age was accompanied by more constraints in physical, sensory and cognitive functioning, and lower HRQoL in the physical domain (PCS), whereas HRQoL in the psychosocial domain (MCS) was preserved, if not slightly improved, with age. In sum, we were able to observe the paradox of well-being phenomenon in our Taiwanese older adults.

Our results also correspond to prior research on terminal decline in subjective well-being, which suggests the increased decline in all health measures, including self-rated health, in proximity to death. The positive association between advanced age and MCS, on the other hand,

was in line with theoretical perspectives emphasizing motivational and self-regulatory mechanisms that allow older adults to maintain psychosocical well-being in the face of health-related losses.

As our results revealed a small and negative correlation between PCS and MCS, it seems reasonable to assume that cross-sectional age trajectories may vary by domains of subjective well-being (McAdams et al., 2012; WHOQoL Group, 1995). Our results also confirmed Kunzmann et al. (2000) suggestion that more pronounced age difference in subjective well-being may be detected in domain- and time- specific assessments as opposed to context- and time-neutral questions.

Perhaps one of the most surprising results was that even with raw data (i.e., not adjusting for SES and other background variables), we saw a small but significant upturn of MCS in our sample. In previous studies (e.g., Chen, 2001; Gopalakrishnan Netuveli, Wiggins, Hildon, Montgomery, & Blane, 2006; Sun et al., 2016), the upturn of SWB and life satisfaction with age could only be seen after controlling for a series of SES and health-related covariates. The relationship shown with the raw data deserved attention as it represents the actual age effect on HRQoL, considering all possible variations in every aspect of life as one ages.

Echoing prior research, it may not be realistic to expect a disease-free older age, considering the consistent cross-sectional associations found between age and constraints in physical and sensory functioning (Katz & Calasanti, 2015; Rubinstein & de Medeiros, 2015). Instead, the robust findings of relatively preserved psychosocial aspects of HRQoL reiterated the need for future research to examine the specific mechanisms that protect older adults from the negative impact of objective health decrements.

Associations among age, objective health status and HRQoL in old age

The second objective was to examine the associations between objective health indicators and subjective HRQoL and observe variations in this association based on age. Consistent with our hypothesis, after controlling for demographic and cognitive covariates, the association between age and PCS was mediated by objective health status. The mediation pathway for age, objective health status and PCS suggested that chronological age may not be the most precise predictor for the inter- and intro-personal differences in PCS. Objective health status, in turn, seems to play a more important role in determining one's PCS. Interestingly, however, while aging is seen as a period of many progressively declines in objective health; the predictive value of objective health status for subjective QoL became weaker with advancing age in this Taiwanese older adult sample. This seemingly counterintuitive result corresponds to the paradox of aging phenomenon found in the prior subjective well-being research in Western and highly industrialized countries.

In contrast to the analyses for PCS, the associations between MCS and objective health did not vary by age, and controlling for objective health even strengthened the observed positive association between MCS and age. As noted in the introduction, variables beyond chronological age, including self-regulation, perceived control, social comparison, and social integration, may potentially affect the association between objective health and MCS and should be explored in future research.

Limitations

Our results need to be interpreted within the context of the study limitations. First, the cross-sectional nature of the study did not allow us to investigate longitudinal shifts in the

associations among age, objective health indicators, and subjective HRQoL. Second, we were unable to determine if the observed age pattern was a result of cohort effects or a genuine representation of the effect of aging. A longitudinal study would provide more insights regarding the relative role of age, age-related differences in effects of objective health on HRQoL, as well as cohort effects in HRQoL. Third, self-reported HRQoL may be subject to various kinds of bias, such as social desirability, that we were unable to evaluate with our dataset. Fourth, the results may not be generalizable due to the fact that our current sample was based on the HALST study, for which a relatively healthier portion of the aging population in Taiwan was selected (Hsu et al., 2017). Finally, the study was part of a larger cohort study, and the research question can only be analyzed within the boundary of the original study.

Conclusion

Notwithstanding these limitations, to the best of our knowledge, this is the first study in a Taiwanese sample that used a well-validated measure of HRQoL to assess age differences in subjective well-being, and examine the effects of age and age-related differences in objective health status to obtain evidence for the paradox of aging in Taiwan. Although, our results may not be comparable to other well-established studies in the West (e.g., the ELSA, the Berlin Aging Study, the Veterans Affairs Normative Aging Study, the World Gallup Poll, the US General Social Survey, the British Household Panel, Eurobarometer, and the National Health and Nutrition Examination Survey etc.) considering the differences in sample characteristics (age groups and health status) and measures (happiness, positive or negative affect, and life satisfaction), our results showed similar conclusions that are complementary to these studies: The third age can be a period with high subjective quality of life.

In summary, these results are consistent with the aforementioned theoretical frameworks, suggesting mechanisms that allow for the preservation of HRQoL, especially MCS, in spite of objective health detriments among older adults. Future studies should systematically evaluate specific psychosocial variables implicated by these theories (e.g., time perspective, perceived control, social and temporal comparisons, or interpersonal embeddedness) (Antonucci et al., 2014; Antonucci & Akiyama, 1987; Carstensen et al., 2000; Chen, 2001; Mather & Carstensen, 2003; Schulz & Heckhausen, 1996; Wilson & Ross, 2000) to examine their relative contributions to the observed age patterns. In the long run, a better understanding of these variables could be leveraged to promote continued HRQoL even among those individuals who face considerable objective health threats in their later years.

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TABLES & FIGURES

Table 1. Baseline characteristics of study sample for complete, included, and excluded sample

	Complete sample	Final sample (completed data)	Excluded (With missing data)
N	5664 (100.0%)	3856 (68.1%)	1808 (31.9%)
Sociodemographics			
Age (year), mean ± SD **	69.6 ± 8.3	69.3 ± 8.2	70.2 ± 8.4
[Min, Max]	[55.1, 104.2]	[55.1, 104.2]	[55.3, 95.4]
Gender			
Male	2676 (47.2%)	1849 (48%)	827 (45.7%)
Female	2988 (52.8%)	2007 (52%)	981 (54.3%)
Education level **			
Illiterate (n, %)	799 (14.1%)	415 (10.8%)	384 (21.3%)
Elementary school	2322 (41.0%)	1540 (39.9%)	782 (43.3%)
Middle school or higher	2539 (44.9%)	1901 (49.3%)	638 (35.4%)
Cognition			
MMSE **	26.2 ± 3.8	26.6 ± 3.4	25.3 ± 4.3
[Min, Max]	[1, 30]	[12, 30]	[1, 30]
Physical functioning			
Handgrip **	29.0 ± 10.1	29.5 ± 10.0	28.0 ± 10.2
[Min, Max]	[2, 64]	[2, 64]	[2, 61]
SPPB **	10.4 ± 2.6	10.6 ± 2.4	9.9 ± 2.9
[Min, Max]	[0, 12]	[0, 12]	[0, 12]
Sensory functioning			
Visual acuity *			
Moderate to severe vision loss (0)	236 (6.1%)	229 (5.9%)	7 (18.9%)
Mild vision loss (1)	1623 (41.7%)	1606 (41.6%)	17 (45.9%)
Normal (score = 2)	2034 (52.2%)	2021 (52.4%)	13 (35.1%)
Health-related quality of life			
Physical component score **	46.8 ± 8.9	47.4 ± 8.5	45.5 ± 9.6
[Min, Max]	[4.5, 71.5]	[4.5, 71.5]	[8.5, 68.2]
Mental component score	59.3 ± 8.1	59.4 ± 8.0	59.2 ± 8.4
[Min, Max]	[5.2, 79.5]	[5.2, 79.5]	[14.8, 78.1]

Note: * p-value<0.05, ** p-value<0.001 for comparison of the final and excluded sample

Table 2. Intercorrelations among full set of variables (n=3,856)

Variables	Age	Female	Edu	MMSE	Hand	SPPB	Vision	PCS	MCS
Age	--								
Female gender	-.052 *	--							
Education Level	-.28 **	-.25 **	--						
MMSE	-.40 **	-.21 **	.61 **	--					
Handgrip strength	-.31 **	-.71 **	.29 **	.35 **	--				
SPPB	-.41 **	-.11 **	.29 **	.43 **	.36 **	--			
Vision	-.38 **	-.085 **	.30 **	.34 **	.26 **	.31 **	--		
PCS	-.25 **	-.13 **	.21 **	.26 **	.31 **	.52 **	.19 **	--	
MCS	.065 **	-.049 *	.020	.068 **	.076 **	.087 **	.0092	-.067 **	--

Note: * p-value<0.05, ** p-value<0.001

Table 3a. Multiple linear regression predicting PCS

	Model 1		Model 2		Model 3		Model 4	
Variables	*B*	β	*B*	β	*B*	β	*B*	β
Age								
Linear	-0.26 (0.016)	-16.0 **	-0.19 (0.018)	10.98 **	-0.012 (0.019)	-0.63	-0.47 (0.057)	-8.25 **
**Gender								
Female			-1.62 (0.27)	-5.94 **	3.78 (0.37)	10.30 **	3.48 (0.37)	9.51 **
Education level								
Elementary			-0.52 (0.51)	-1.03	-0.18 (0.48)	-0.38	-0.33 (0.48)	-0.68
Middle or higher			0.57 (0.56)	1.02	0.91 (0.54)	1.71	0.92 (0.53)	1.74
MMSE			0.37 (0.051)	7.28 **	0.19 (0.049)	3.77 **	0.13 (0.049)	2.64 *
Objective health status					0.37 (0.017)	20.74 **	-0.40 (0.092)	4.38 **
Age* objective health status							0.011 (0.0013)	8.52 **
R^2	0.0624		0.1072		0.1969		0.2118	
ΔR^2	--		0.0448		0.0897		0.0149	
Test	--		48.29 **		430.17 **		72.56 **	

Note: N = 3,856; B: unstandardized coefficient; β: standardized coefficient. Regression coefficients were significant at * p-value<0.05, ** p-value<0.001

Table 3b. Multiple linear regression predicting MCS

	Model 1		Model 2		Model 3		Model 4	
Variables	*B*	β	*B*	β	*B*	β	*B*	β
Age								
Linear	0.063 (0.016)	4.03 **	0.10 (0.017)	5.88 **	0.16 (0.019)	8.45 **	0.22 (0.059)	3.68 **
Gender								
Female			-0.42 (0.27)	-1.57	1.43 (0.38)	3.79 **	1.47 (0.38)	3.86 **
Education level								
Elementary			-0.61 (0.50)	-1.22	-0.49 (0.49)	-0.99	-0.47 (0.49)	-0.96
Middle or higher			-0.91 (0.55)	-1.65	-0.79 (0.55)	-1.44	-0.79 (0.55)	-1.45
MMSE			0.29 (0.050)	5.85 **	0.23 (0.051)	4.53 **	0.24 (0.051)	4.61 **
Objective health status					0.13 (0.018)	6.92 **	0.21 (0.095)	2.24 *
Age* objective health status							-0.0013 (0.0013)	-0.94
R^2	0.0042		0.0160		0.0280		0.0282	
ΔR^2	--		0.0118		0.0120		0.0002	
Test	--		11.50 **		47.83 **		0.88	

Note: N = 3,856; B: unstandardized coefficient; β: standardized coefficient. Regression coefficients were significant at * p-value<0.05, ** p-value<0.001

Figure 1. A flowchart of the data collection process and attrition for the HALST study (baseline: 2009-2013), and the data selection for the current study (n = 3,856)

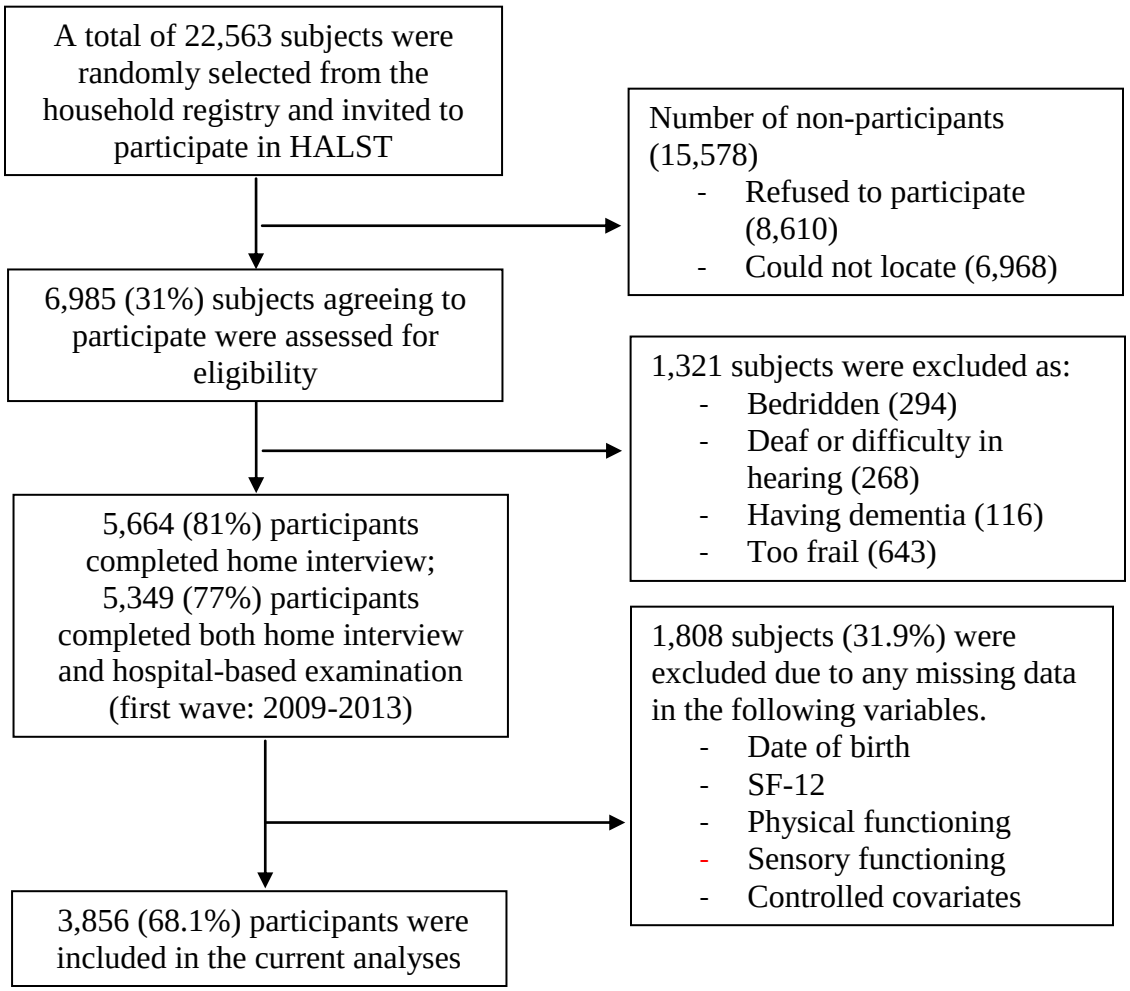

Figure 2. LOESS fitted age curves for PCS and MCS. Data are shown as weighted average raw scores for the final sample (n=3,856).