# Mental well-being in old age: distribution, determinants and consequences

By Jingjing Wang MSc

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Health Sciences

September 2019

University of Warwick

Warwick Medical School, Department of Health Sciences

# Contents

# I. List of tables

# II. List of figures

## III. List of abbreviations

| | |
|---|---|
| **ABS** | Bradburn’s Affect Balance Scale |
| **ADLs** | activities of daily living |
| **BHPS** | The British Household Panel Survey |
| **CD** | chronic disease |
| **CI** | confidence interval |
| **DS** | demographic & socio-economic |
| **FL** | functional limitations |
| **GH** | general health |
| **HR** | hazard ratio |
| **HSCIC** | Health & Social Care Information Centre |
| **HSE** | the Health Survey for England |
| **IADLs** | Instrumental Activities of Daily Living |
| **LGBT** | lesbian, gay, bisexual, and transgender |
| **LS** | life satisfaction |
| **LSIA** | Life Satisfaction Index-A |
| **MCS** | mental health composite scores |
| **MHC-SF** | Mental Health Continuum Short Form |
| **MMAT** | Mixed Methods Appraisal Tool |
| **MWB** | mental well-being |
| **NOS** | Newcastle Ottawa Scale |
| **ONS** | Office for National Statistics |
| **OLS** | the ordinary least squares |
| **OPQOL** | Older People's Quality of Life |
| **OR** | odds ratio |
| **OWB** | objective well-being |
| **PA** | physical activity |
| **PANAS** | Positive and Negative Affect Schedule |

| | |
|---|---|
| **PCS** | physical health composite scores |
| **PF** | psychological factors |
| **PGWBI** | The Psychological General Well-Being Index |
| **PH** | physical health |
| **PWB** | psychological well-being |
| **QA** | quality assessment |
| **QALY** | quality-adjusted life year |
| **GHQ-12** | the 12 questions of the General Health Questionnaire |
| **QoL** | quality of life |
| **RCT** | randomized controlled trial |
| **RR** | relative risk |
| **Ryff's PWB** | Ryff's Psychological Well-Being Scales |
| **SE** | standard error |
| **SEM** | structural equation modelling |
| **SES** | socio-economic status |
| **SF** | social functioning |
| **SF-12** | The 12-item short form health survey |
| **SF-36** | The 36-item short form health survey |
| **SPANE** | Scale of Positive and Negative Experience |
| **SWEMWBS** | the Short Warwick-Edinburgh Mental Well-being Scale |
| **SWB** | subjective well-being |
| **SOC** | selection, optimization and compensation |
| **UKHLS** | the UK Household Longitudinal Study |
| **WEMWBS** | the Warwick-Edinburgh Mental Well-being Scale |
| **WHO** | the World Health Organization |
| **WHOQOL-OLD** | World Health Organization Quality of Life – old |

# IV. Acknowledgements

I would like to acknowledge the help and support of many people throughout my PhD study.

Firstly, I would like to thank my supervisors Professor Scott Weich, Professor Max Birchwood and Professor George Tadros for providing the opportunity for me to undertake this PhD. I appreciate your knowledge and guidance. In particular, I would like to thank Professor Scott Weich for his vital support, interest, patience and expertise. Thank you so much, indeed for holding my hands during this PhD journey. I am extremely grateful for this opportunity to work with and being supervised by you. This PhD would not have been the same without you.

I would like to thank Muna Dubad, Dr Catherine Winsper, Daniel Gallacher and Professor Scott Weich for their help on the systematic reviews. I would also like to thank Dr Laura Kudrna for her interest and expertise on my PhD topic. Additionally, I would like to thank my colleagues in the farmhouse, particularly, Muna Dubad, Rebecca Crosby, Sian Williamson, Becky Appleton, Zain Ahmed, and Farah Elahi. The best thing that happens to me is the friendships, the love, and the sheer joy we have shared during our PhD journey together. With you accompany, this PhD is not a lonely journey.

My family are the biggest support and motivation for me. They have been supporting my academic career for many years. Most of all I would like to thank my husband Yang for his understanding, supporting and sacrificing. We both sacrificed so much for my pursuit. I know it must be tough for you. Thank you for loving me and supporting me.

This PhD thesis is dedicated to my grandparents, who both passed away during my PhD. They had taught me and demonstrated for me every day what love is. They were my motivation and inspiration to uptake a PhD on older people's mental well-being. I love you forever.

# V. Declaration and signed statement

This thesis is submitted to the University of Warwick in support of my application for the degree of Doctor of Philosophy. It has been composed by myself and has not been submitted in any previous application for any degree.

Signed statement

I am aware of the University regulations governing plagiarism and I declare that this document is all my own work except where I have stated otherwise.

Signed ......................................................................

Name ......................................................................

Date ......................................................................

# ABSTRACT

**BACKGROUND:** We know a lot about illness, but we do not know as much about wellness. The positive psychology movements over recent decades have improved our understanding of wellness a lot. However, the current research on mental well-being (MWB) is still lacking in integrated evidence on the multifactorial association between MWB and its determinants and the incorporated effects of these determinants on MWB. Moreover, there is a dearth of research on the consequences of MWB in later life beyond associations with mortality. Furthermore, what is new to the current knowledge of MWB is whether MWB could mediate and moderate the association between later-life risk factors and ageing well.

**AIM:** This thesis draws on the central question of the epidemiology of MWB in older age, from its distribution, determinants and consequences. The overall aim of this PhD research is to discover whether MWB influences outcomes associated with ageing and how it is associated with ageing well.

**METHODS:** This thesis provided integrated quantitative evidence drawing on the Health Survey for England and the UK Household Longitudinal Study. It consisted of three phases: Phase 1. Preliminary research which included two parallel systematic reviews of the literature on the relationship between later life risk factors and MWB, and epidemiological findings on MWB consequences. Phase 2. Secondary data analysis to describe the distribution, investigate the determinants and explore the possible consequences of MWB in later life, and unveil the impact of MWB on ageing well. Multiple regression analysis and mixed-effects modelling were used to examine the determinants of older people's MWB. The association between MWB and its consequences was analysed using a random-effects model. The mediation effect of MWB on the association between general health and physically ageing well (PCS) was analysed using structural equation modelling and path analysis, while the moderation effect of MWB was analysed using multiple regression and logistic regression. The Cox proportional hazards regression and a Kaplan-Meier survival curve were used to investigate the lost to follow-ups. Phase 3. Discussion and integrated findings with policy implementation ideas.

**RESULTS:** The distribution of MWB generally displayed a slightly inverted ‘U-shape' (convex relationship) in old age after controlling for physical health and demographic & socio-economic variables. The results from the cross-sectional analysis and longitudinal analysis provided statistical evidence of the determinants of older people's MWB. In summary, ill-health (both physically and mentally), poor sleep quality and financial situation were all significantly associated with low MWB. On the other hand, being retired or remain employed, being married, being female, having a higher qualification level and being religious were all significantly associated with high MWB. Mental illness and physical health were demonstrated to be the most influential factors over all other determinants of older people's MWB. This PhD also confirmed that retaining MWB was a vital criterion of ageing well. MWB could enhance physically ageing well longitudinally. Moreover, what is new to the current knowledge of MWB is that MWB could mediate and moderate the association between general health and physically ageing well (PCS) even after controlling for demographic & socio-economic variables and psychological variables.

**CONCLUSION:** This PhD underlined a critical message that MWB plays both roles as a critical outcome and a determinant of physical wellness. Furthermore, MWB was a protector against later-life risks. This PhD thesis is the first research that links the

distribution, determinants and consequences of MWB in old age. It could add value to the knowledge of MWB and promote MWB through policy initiatives.

# CHAPTER 1 INTRODUCTION

This chapter sets out the motivation to the thesis and highlights the interest of examining the epidemiology of mental well-being (MWB) in old age from its distribution, determinants and consequences. The overall research aim of this PhD thesis is then briefly introduced in this chapter. Finally, this chapter outlines the overall structure of the thesis.

Although advanced ageing is associated with physical and cognitive decline, MWB is generally found to be higher in older people than younger adults. However, between-individual variation in MWB has also been found to be larger in older people than in younger adults. The current research on MWB lacks integrated evidence on including the distribution, determinants, and consequences of MWB in one study. Additionally, the multifactorial association between MWB and its determinants has rarely been examined in a single study. Hence, the cumulative effects of these determinants on MWB remain uncertain. Moreover, there is a dearth of research on the consequences of MWB in later life beyond associations with mortality. What is new to the current knowledge of MWB is whether MWB could mediate and moderate the association between later-life risk factors and ageing well.

The study population in this PhD thesis was community-dwelling older people in the UK. Older people were defined as populations aged 60 or above, according to the United Nations' use of old age (UN, 2001). The analyses undertaken in this PhD were based on secondary analysis of data collected as part of two large UK survey datasets: The Health Survey for England (HSE) and Understanding Society - the UK Household Longitudinal Study (UKHLS).

This thesis draws on the central question of the epidemiology of MWB in older people, from its distribution, determinants and consequences. The overall aim of this PhD research is to discover whether mental well-being (MWB) influences outcomes associated with ageing and how it is associated with ageing well. The overall structure of the thesis is outlined below:

Chapter 1 Introduction – provides an overview of the structure of this PhD thesis.

Chapter 2 Background – provides the theoretical background of ageing and MWB. The paradox of ageing and MWB and the research background are also discussed.

Chapter 3 Methodology & Justification – sets the overall aims & objectives, justifies the research questions, generates the research hypotheses and outlines the research gap & overall rationale for this PhD thesis. The measurements of MWB and ageing well that are suitable for use in older people are also reviewed and discussed. Methodologies undertaken in this thesis are detailed, and an overview of the research strategy is provided.

Chapter 4 Factors related to MWB in Community-Dwelling Older People: A Systematic Review – presents the results of a systematic review of existing literature on the later-life risk factors associated with MWB in old age. Potential aetiological factors are separated into five categories: physical health and functioning; social functioning; behavioural and lifestyle; psychological; and demographic and socio-economic factors

Chapter 5 Consequences of MWB in Community-Dwelling Older People: A Systematic Review – presents the results of a systematic review of existing literature on the consequences of MWB in old age. Narrative quantitative analysis is undertaken to examine the MWB consequences of reducing mortality.

Chapter 6 The Distribution of MWB in Old Age: 7-year Cross-sectional Study Using HSE – presents the descriptive results of the distribution of MWB using the HSE 7-year datasets. Micro-scoping in on older people's MWB variations in distribution with different age bands is used when analysing older people’s MWB.

Chapter 7 The Determinants & Consequences of MWB in Old Age: 9-year Longitudinal Study using UKHLS – presents the results of secondary data analysis of the distribution, determinants and consequences of MWB using UKHLS 9-year datasets.

Chapter 8 Discussion & Conclusion – integrates and discuss the findings of this PhD thesis.

# CHAPTER 2 BACKGROUND

## 2.1 INTRODUCTION

Mental well-being (MWB) is a broad concept ranging from subjective accounts of individual's happiness to fulfilment or satisfaction of a given list of capabilities, functioning or needs. It includes both positive functioning and positive feelings (Stewart-Brown, 2015, 2018). Ageing is a complex process that involves many factors other than chronology (Hooyman & Kiyak, 2011). It represents a biopsychosocial phenomenon encompassing physical, psychological and social changes. Although there are many ageing theories that attempt to explain the mechanisms of age-related changes, none of them is sufficient to explain the process of ageing exclusively. This chapter does not aim to include an all-encompassing review of the ageing theories literature. Instead, it aims to provide the theoretical background and context for the current work with a specific focus on the psychological theories that explain the association between MWB and old age. The intersectionality in the biological, psychological and sociological theories of ageing is also a matter of interest to the analysis of MWB determinants in old age. Specifically, what are the physical, psychological and socio-demographic factors associated with MWB in old age? In addition, this chapter also aims to introduce the age - MWB association that would be tested in chapters 6 & 7 through descriptive analysis and regression analyses by controlling personal characteristics.

## 2.2 THEORETICAL BACKGROUND - AGEING

### 2.2.1 DEFINITION OF AGEING

This chapter will begin with a broad overview of several selected theories of ageing under the three widely used aspects, namely biological, psychological and sociological (Baltes et al., 2012).

*Biological ageing*

Ageing is the process of becoming older. At the biological level, ageing is associated with the gradual accumulation of molecular and cellular damage (WHO, 2015) which eventually results in a general decline in physical health and functional capacity and an increased risk of frailty and chronic diseases (Kirkwood, 2008). Ageing is a significant risk factor for developing common neurodegenerative diseases, such as Huntington's disease, Parkinson's disease and dementia including Alzheimer's disease (John, 2010). The study of the biology of ageing is concerned with understanding the processes that underlie ageing and age-related diseases.

Biological theories of ageing fall into three categories: stochastic theories, developmental-genetic theories and evolutionary theories (Baltes et al., 2012). While stochastic theories explain ageing as events that randomly occur in living organisms and accumulated over time, developmental-genetic theories suggest that ageing is regulated by genetically controlled development. Evolutionary theories view ageing as a result of the declining effect of the natural selection process (Baltes et al., 2012). Natural selection may even select for pleiotropic genes that benefit fitness early in life but cause functional decline and ageing phenotypes later in life (Williams, 1957; Baltes et al., 2012). Although genes might remain relevant in determining function at old age and changes in function with age, the effects of very early life events and people's development at different life stages also significantly influence the ageing process. The biological ageing theory is therefore weak in explaining why people age differently since it is based on natural progressions and yet sees ageing as an all-negative process at old age.

*Psychological ageing*

Beyond the biological declines listed above, old age frequently involves other significant shifts and losses such as those of role and social position as well as those of close relationships. Broadly, psychological theories of ageing include areas of learning, memory and development (Baltes et al., 2012) and refer to both psychological changes related to ageing and adaptive psychological mechanisms to cope with age-related losses (Wernher & Lipsky, 2015). Compared with biological theories of ageing, psychological theories of ageing initially argued that ageing is not a one-dimensional process of decline but raise the possibility of gains as well (Wernher & Lipsky, 2015). Although many older people experience cognitive decline, such a decline is not universal (Schaie, 2008). Moreover, with the increased use of psychological coping strategies, older people may maintain higher levels of emotional integration and control (Schaie, 2008). Since psychological theories of ageing are the conceptual basis for understanding, analysing and designing ways to investigate mental well-being in old age, this chapter will consider the psychological theories of ageing in more detail.

Psychological theories of ageing combine objective (behavioural) and subjective (meaning-making) features of ageing (Baltes et al., 2012), and revolve around the lifespan development process. These theories may be classified as cognitive theories, stage theories and systematic theories, including adaptive approaches related to frameworks of lifespan development (Baltes et al., 2012).

*'Cognitive theories'*. 'Two-component theories of intellectual development' consider the functional organization of intellectual abilities as "dynamic – developing and transforming" over the lifespan (Li et al., 2004, p. 155). The two components of individual intellectual development are fluid intelligence, which is presumed to depend on biological and genetic factors, and crystallized intelligence, which is presumed to depend on experience and culture-based knowledge (Horn, 1982). Fluid intelligence is the native ability to reason in abstract terms and solve problems. Crystallized intelligence is the ability to acquire knowledge and skills. Previous research generally agrees that there is a "lead-lag pattern" (Li et al., 2004, p. 157) between fluid and crystallized intelligence trajectories over the lifespan. A person's fluid intelligence develops and grows earlier than crystallized intelligence and naturally decreases with age after reaching its maximum around mid-twenties. On the other hand, crystallized intelligence reaches its maximum in the forties, and remains relatively stable until declining in the seventies (see Figure 1 below). Cognitive theories of ageing align closely with the biological theory of ageing discussed earlier, in that both theories suggest that ageing occurs due to the declining effect.

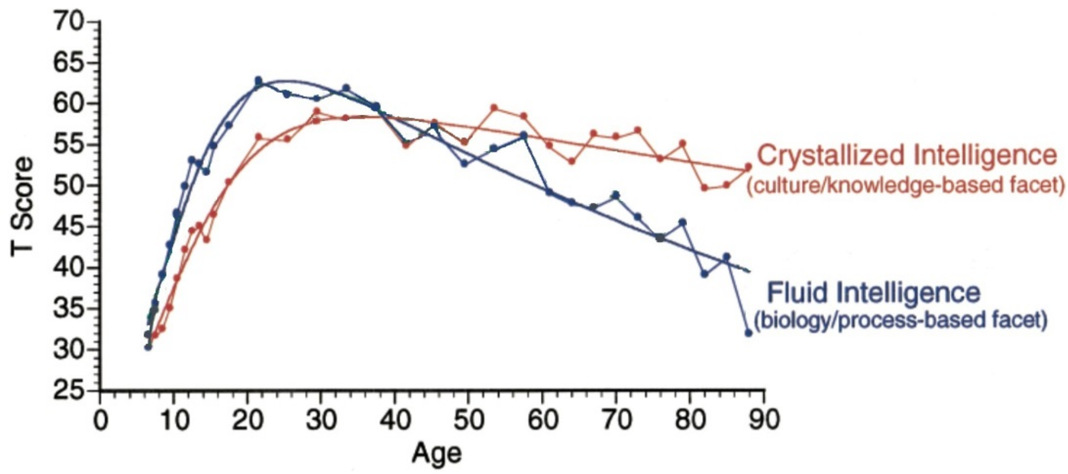



*Figure 1. Age gradients of fluid intelligence and crystallized intelligence (adapted from Figure 1. Li et al., 2004, p.158)*

*'Stage theories'*. The best-known stage theories are Erikson (1982)'s 'stage model of psychosocial development' and Schaie & Willis (2000)'s 'stage theory of cognition'. Erikson (1982) suggested that human development progresses via psychosocial development from a psychological mind and social environment and relationships. He argued that psychosocial development throughout one's life could be presented as eight stages of ego development with conflicts – 'psychosocial crises' – appearing at each stage (Erikson, 1998). Potential 'syntonic'(positive) outcomes or 'dystonic' (adverse) outcomes might arise from each of the eight crisis stages. People who resolved crises successfully could display healthy psychological adjustment, whereas those who resolved crises unsuccessfully could damage their personality development. In Erikson's theory, ego was responsible for a sense of personal identity, which positively contributed to psychosocial development by mastering attitudes, ideas and skills. Erikson (1998) viewed old age as the 'ego integrity stage' where the conflict was 'integrity' versus 'despair'. When older people review their lives, those who found a sense of integrity, feeling satisfied and fulfilled with life, were recognised as having coped successfully with their ageing process. On the other hand, those feeling unproductive and unsatisfied with life

might develop end of life despair (Erikson, 1979, 1982; Haight et al., 1994; Schaie, 2008). However, Erikson (1998)'s model lacked in-depth analysis of psychosocial development within old age since he lumped older people together into one group and viewed old age as a single stage of reviewing one's life.

More recently, Schaie & Willis (2000)'s stage model raised attention in psychological theories of ageing. They formulated an eight-stage adult intellectual development theory, in which adult intellectual development consists of different use of intellect when acquiring information and knowledge at each stage. With a detailed analysis of cognition development in old age, they classified old age (beyond the age of 60 or 65) as young-old age, middle-old age and oldest-old age, referring to the ‘reorganizational stage’, ‘reintegrative stage’ and ‘legacy creating stage’ (see Figure 2 below). The ‘reorganizational stage’ was proposed immediately after the ‘responsible stage’. In this stage, cognitive capacity and intellect reorganised for activities directed towards planning utilisation of resources after retirement and for the remaining period of life. The ‘reintegrative stage’ included a shift of interest to acquire information and knowledge that was more selective and centred on self-needs in later years. Cognitive activities at this stage aimed at maintaining the required quality of life when facing increasing fragility. Once the reintegrative efforts been completed, older people might gain better life qualities (Schaie, 2008). Although not all, many older people may still arrive at the ‘legacy creating stage’ – oldest old age – with a relatively ‘clear mind, albeit frail body' (Schaie, 2008). Cognitive activities carried at this stage included life review or even a written history of life.

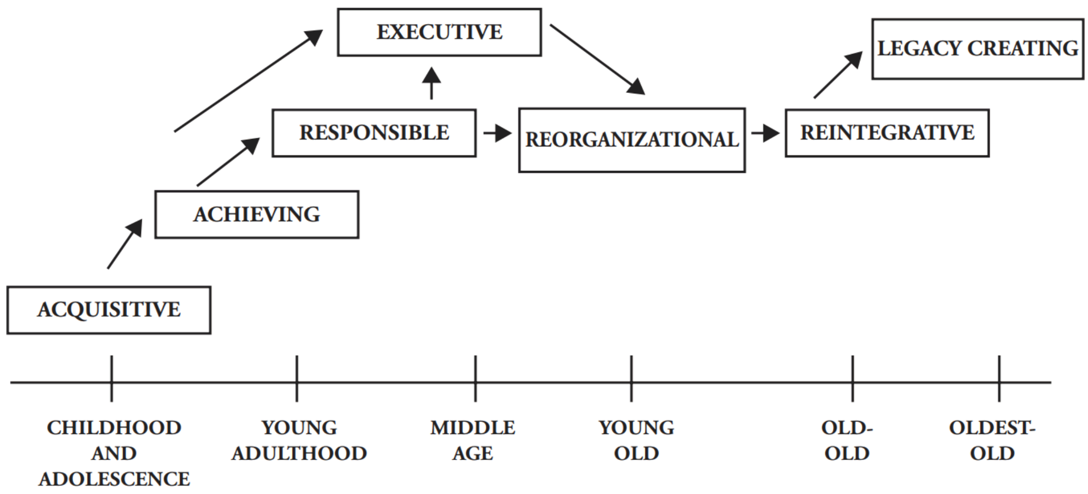



*Figure 2. Stage theory of cognition (adapted from Figure 10.1 Schaie & Willis, 2000, p.176)*

Stage theories suggest that psychological gains and losses occur at every life stage. Older age is much like younger age but still has its specific challenges. These challenges could lead to either greater or lesser life satisfaction. Moreover, people's current stage of psychological health is shaped by successfully passing through the previous stage's challenges. However, stage theories lack empirical support (Baltes et al., 2012).

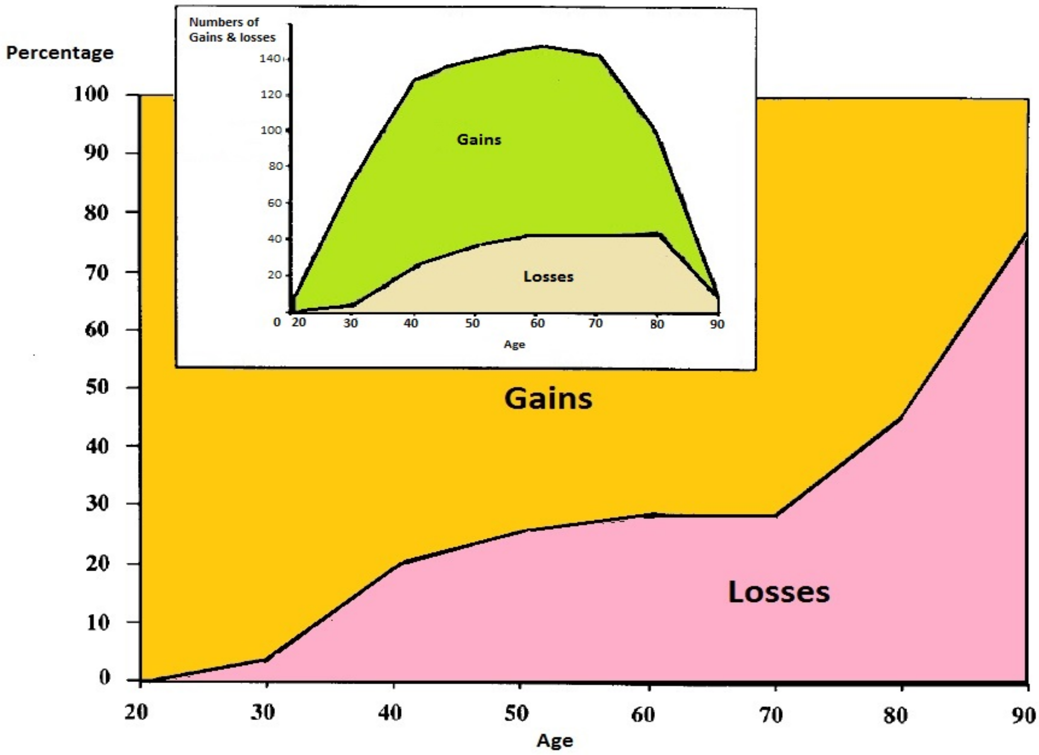
*'Systematic theories'* – *'Adaptive approaches'* focus on the resources allocation and the goals achieving mechanisms behind the adaptive regulation of lifespan development (Riedinger et al., 2006). There are four better-known approaches: 1) 'socio-emotional selectivity theory' suggests that in old age when future time perspective is perceived as limited, emotional-related goals are more likely to be achieved; 2) 'dual-process model of assimilative and accommodative coping' suggests that in old age when losses become more common, adaptiveness of accommodative process that adjusted goals to situational constraints increases; 3) 'optimization in primary and secondary control' suggests that in old age when primary control fails to modify the environment, secondary control of self-protective compensatory will take place; and 4) 'the meta-model of selection,

optimization and compensation (SOC)' suggests that in old age when goal-related resources are limited, optimization of the remaining resources could help older people maintain a given level of functioning. The SOC framework is recognised as a general framework of adaptive development in different age groups and its implementation in self-reported questionnaires has also been widely noticed (Riedinger et al., 2006). This chapter will consider Baltes & Baltes's (1990) SOC model in detail. The SOC model speaks of the orchestration of three processes: selection (of personal goals), optimization (of goal pursuit) and compensation (of losses in goal-relevant resources) (see Table 1 below).

*Table 1. Selection, Optimization, and Compensation embedded in an action-theoretical framework (adapted from Table 1. Freund & Baltes, 2002, p. 643)*

| Selection (goals/preferences) | Optimization (goal-relevant means) | Compensation (means for counteracting loss in/ blockage of goal-relevant means) |
|---|---|---|
| Elective selection | Attentional focus | Substitution of means |
| Specification of goals | Seizing the right moment | Use of external aids/help of others |
| Goal system (hierarchy) | Persistence | Use of therapeutic intervention |
| Contextualization of goals | Acquiring new skills/resources | Acquiring new skills/resources |
| Goal commitment | Practice of skills | Activation of unused skills/resources |
| Loss-based selection | Resource allocation (effort, time) | Changes in resource allocation (effort, time) |
| Focusing on most important goals | | |
| Reconstruction of goal hierarchy | Modeling successful others | Modeling successful others who compensate |
| Adaptation of standards | | |
| Search for new goals | | Neglect of optimizing other means |

The SOC model represents the dynamics between gains and losses across different periods of lifespan. Gains/losses corresponds to the desirable attributes increasing/decreasing with age. The SOC model argues that lifespan development combines both gains and losses and their shift in proportion with ageing. The proportion of gains decreases with age while the proportion of losses increases with age (see Figure 3 below). In old age, although ageing is associated with increased risk of fewer resources gained and more resources lost, gains greatly exceed losses throughout early old age. Once people reach older-old age (80+), losses exceed gains. However, even at the oldest-old age (90+), there is still 20% of expected gains (see Figure 3 below).




Note: Gains and losses were presented as by percentage and by numbers

*Figure 3. Subjective expectations of gains and losses in resources across the lifespan (adapted from Figure 5. Heckhausen et al., 1989, p. 117)*

The SOC model could be understood as an adaptive approach concerned with the ways that people are maximising gains and minimising the losses associated with ageing, thus promoting successful ageing (Riedinger et al., 2006). Baltes et al. (2012) reiterated that the SOC theory focuses on individuals as well as context as a whole and considers ageing as a lifelong process. Older people who successfully adopted SOC strategies might benefit from increased resources through developmental enhancement, maintained functioning when facing challenges and controlling impending losses (Baltes & Baltes, 1990). The primary mechanism behind the SOC is that a selection process gives individual non-random directions. Older people will select and adjust their goals and coping strategies. When the current attempts are unsuccessful, self-protective compensatory strategies will automatically take place. This could also distinguish psychological theories from the biological theories which view ageing as a natural declining process.

*Sociological ageing*

Sociological theories of ageing focus on explaining the changes of roles, relationships and responsibilities that occur in old age (Hooyman & Kiyak, 2011). Early sociological theories, including disengagement theory, are no longer viewed as viable since they theorised that, as people entered old age, they would disengage from specific roles (e.g. employment) and be exempted from certain responsibilities and societal obligations (Henry & Cumming, 1959). However, more recent empirical studies find an increasing number of older people remain employed, healthy, socially involved and integrated (Hooyman & Kiyak, 2011). Societal changes shaped sociological theories to conceptualise that ageing consists of the experience of changing social roles along with a biopsychosocial process. Activity theory, on the other hand, is more preferred in recent decades as it assumes that maintaining active and health and engaging in social activities are crucial elements of successful ageing (Rowe & Kahn, 1987). However, within the sociological theories of ageing, variables that might cause inequalities such as ethnicity, gender and socio-economic status are only minimally considered. New theoretical perspectives considering diverse cultures, contexts and circumstances need to be developed (Hooyman & Kiyak, 2011).

### 2.2.2 DEFINITION OF 'AGEING WELL'

Understandings of what it means to age well draw upon different theories of ageing. The phrase 'ageing well' is also interchangeably used with 'healthy ageing', 'flourishing' and 'successful ageing'. Ageing well is defined in this PhD as a state of doing, living and functioning well physically, psychologically and socially. Fernández-Ballesteros et al. (2009) reviewed that 'ageing well' (and related concepts such as 'active', 'productive', 'positive' or 'optimal' ageing) were commonly constructed or used to mean similar things. This chapter will use 'ageing well' as an umbrella term for all of the following dimensions: 'ageing well', 'healthy ageing', 'flourishing' in later life and 'successful ageing'.

*'Ageing well'*

'Ageing well' is often used interchangeably or alongside 'healthy ageing' in public policy and focuses mostly on physical functioning. In cross-cultural studies of aging, good physical health and functional status have been associated with aging well (Fry et al., 1997; Hawkins, 2005). However, physically aged well or functioned well might not be achievable by every older people, particularly those with multiple comorbidities or severe impairments. On the other hand, successful psychological and social ageing are achievable by most older people. 'Ageing well' is commonly associated with sociological theories of ageing. It emphasises the significance of interactions between older adults and their social environments and networks, and provides implementation support to assist public policy to meet the challenges in an ageing society. Studies of older people indicated that they view happiness, feeling useful, being socially engaged and productive as crucial elements of ageing well (Gale et al., 2013).

*'Healthy ageing'*

‘Healthy ageing’ is promoted by the World Health Organization (WHO) as recognising factors beyond health and social care that have a significant effect on health and well-being, such as building and maintaining relationships as well as contributing to society (WHO, 2015). The word ‘health’ is more than the absence of illness and represents a presence of wellness. There are many concepts of ‘healthy ageing’ and what it means to age in a healthy way. Previous studies used to link ageing with health and frailty discourses in biomedical literature with a reflection of biological theories of ageing. They have been focused on the concept of healthy ageing as the process of decreasing morbidity and increasing longevity (Bryant et al., 2001; Dychtwald, 1999). However, more recent studies also link healthy ageing with psychological theories of ageing. Healthy ageing is, therefore, more about how we feel and function, both physically and mentally (Gale et al., 2013).

*‘Flourishing’ in later life*

‘Flourishing’ as adopted by psychological theories of ageing captures the idea of ‘successful ageing’ in later life but locates it in ethical and moral discourses. It explores what makes life worth living. In this context, ageing well is often defined as a state of doing, living and functioning well psychologically and socially, not merely feeling good (Momtaz et al., 2016).

*‘Successful ageing’*

‘Successful ageing’ has become a key and pervasive (if contested) concept, particularly in psychological theories of ageing. Schaie & Hoffer (2001) concluded from a variety of studies in psychological theories of ageing that there were four significant patterns of ageing trajectories suggested by individuals' normative cognitive declines level. The most common pattern is ‘normal ageing', which suggests most individuals follow average trajectories, maintaining a plateau after early midlife until their late 50s or early 60s, starting with cognitive decline during the ageing process, and experiencing modest decline on most cognitive abilities in their early 80s and greater decline nearing the end of life (Bosworth et al., 1999; Schaie, 2008). A few people who maintain their overall level of cognitive functioning until shortly before their demise experience ‘successful ageing’ (Fillit et al., 2002). Some people decline earlier in their cognitive abilities and experience greater than average development of ‘mild cognitive impairment' (Petersen et al., 1999). The rest of those who develop neuro-pathologies or psychopathologies may be clinically diagnosable as living with dementia.

Although psychological theories of ageing are the theoretical basis for ageing successfully, biological and sociological theories also jointly explain how successful or normal ageing could be enhanced. Initial models of successful ageing were used to interrogate cohort studies of epidemiological data in the context of health outcomes (Satariano, 2013) which, in part, explains the moral dichotomy presented by the idea of success or failure in the ageing process. One of the most influential models was Rowe & Khan's (1987, 1997), which first differentiated the concept of ‘successful' ageing from ‘usual' ageing by categorising three key aspects: low risk of disease and disability, high physical and mental functioning, and active engagement with life including productive activity. Bowling relates the interest in and adoption of ‘successful ageing' to "substantial increases in life expectancy at birth achieved over the previous century, combined with medical advances, escalating health and social care costs, and higher expectations for older age", all of which "have led to international interest in how to promote a healthier old age and how to age ‘successfully'" (2005b, p. 1548).

However, what is meant by ‘successful ageing' is different across studies. Cosco et al. (2014) found 105 operational definitions of ‘successful ageing' in their study, exemplifying the multi-dimensional nature of 'successful ageing' and difficulty in categorizing ageing in these ways. Bowling (2007) suggests one reason that successful ageing literature spawns such a range of definitions, saying that they reflect the academic disciplines of the investigators who link successful ageing to their different theoretical underpinnings and perspectives.

Early empirical studies in psychological ageing were targeted at the area of memory, learning, sensation and perception, psycholinguistics and psychometrics (Baltes & Batles, 1990). However, later studies have increasingly focused on the sociological factors that associate with older people's mental health, such as caregiving (Brodaty et al., 2003; Sorense et al., 2002), living in care homes (Mann et al., 2000; Mozley et al., 2004) and needs of care (Banerjee, 1993; Mozley et al., 2004). While previous research has emphasised absence of disease and the maintenance of physical and mental functioning as the keys to 'successful ageing', more recently, psychosocial conceptualizations have emphasized life satisfaction, active engagement with life, positive adaptation, self-rated successful ageing and personal growth in the definition of 'ageing well' (Bowling, 2005b; Jeste et al., 2010). The vital role mental well-being plays in 'successful ageing' or 'ageing well' at this stage is essential to explore.

## 2.3 THEORETICAL BACKGROUND – MENTAL WELL-BEING

Ageing studies in recent decades not only focused on increasing human lifespan but also aimed at increasing human health span. WHO defined 'Health' on 7 April 1948 as 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity'. This definition has not been amended since 1948 and suggested equally importance of physical, mental and social well-being to health. However, older people are often reviewed as a burden to society and resources, and ageing is also reviewed as a negative determinant to health. Physical well-being is less likely to be achieved by older people who have multiple comorbidities or severe impairments. Despite this, many older people continue to make substantial social, economic, and cultural contributions. Ageing well, therefore, cannot be simply assessed by measures that focus mostly on physical functioning (i.e. active ageing) or measures that are focusing mostly about deficits (i.e. quality of life, and disability-adjusted life years) but can be enhanced by measures that improve both health and functioning (i.e. mental well-being). Mental well-being (MWB) is a broad concept ranging from subjective accounts of individuals' happiness to fulfilment or satisfaction of a given list of capabilities, functioning or needs. It comprises both positive feelings and positive functioning (Stewart-Brown, 2018a, p. 504). Although there are various definitions of MWB, it is generally seen as including emotion (affect/feeling), cognition (perception, thinking, reasoning, positive psychological functioning), social functioning (relations with others and society) and coherence (sense of meaning and purpose in life) (Friedli, 2009; Barry & Friedli, 2008). In recent years, there has been growing interest in the measurement of mental well-being and in measures to promote mental well-being. Social scientists and economists have adopted two traditions that collected those different approaches under the labels of subjective well-being (SWB) and objective well-being (OWB) studies (Stewart-Brown, 2018a, p. 503). In the past two decades, ‘happiness’ from a SWB approach became a worldwide measure of national well-being and is proposed by many governments and policymakers, from the fourth Dragon King of Bhutan (1972) to the former French President, Nicolas Sarkozy (2009) and the UK Prime Minister, David Cameron (2010) (Ura, 2012; Allen, 2014). However, Ryan & Deci (2001) suggested that MWB is not best captured by hedonic conceptions of ‘happiness' alone. Mental well-being, by its broader definition from psychologists and philosophers, includes states of happiness and life satisfaction (the hedonic perspective) and positive psychological functioning, good relationships with others and self-realisation/acceptance (the eudaimonic perspective) calls for in-depth knowledge.

### 2.3.1 DEFINITION OF 'MENTAL WELL-BEING'

The concepts of MWB and commonly used measures of MWB will be discussed in more detail in the next chapter, 'Methodology and Justification'. This chapter only lists a few commonly and interchangeably used terms of MWB: mental well-being, psychological well-being, life satisfaction, quality of life and happiness.

*'Mental well-being'*

There are many different definitions of MWB. In health literature, the common definition of MWB is interchangeably used with the WHO's definition of mental health – "a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community" (WHO, 2014, https://www.who.int/features/factfiles/mental_health/en/). However, the WHO's definition of mental health only relates to functioning, without mentioning the MWB constituent component reflecting feeling. In this thesis I used the original definition of MWB as comprising both positive feelings (hedonic well-being) and positive functioning (eudaimonic well-being) (Stewart-Brown, 2015, 2018). The hedonic perspective of well-being reflects on the emotional well-being in research and measures the positive affect, happiness and satisfaction with life. The eudaimonic perspective of well-being reflects on the psychological and social well-being and measures individual's functional status of achieving purpose, integration, contribution, autonomy, intimacy, acceptance, and mastery in life (Keyes & Simoes, 2012). In practice, MWB may include an individual's psychological well-being (self-confidence, agency, autonomy, positive focus and optimism), emotional intelligence (positive relationships with others), and positive affect or happiness (the capacity to experience happiness and contentment).

*'Psychological well-being'*

'Psychological well-being' (PWB) can have various aspects. However, positive psychology explains well-being in terms of experiencing positive feelings (affects and emotions) and having a purpose in life (Taneva, 2016). Ryff (1995, p. 103) argued that "to be well psychologically is more than to be free of distress or other mental problems". She proposed a complex 6-dimensional model of psychological well-being, including 'autonomy', 'purpose in life', 'positive relationships', 'personal growth', 'environmental mastery' and 'self-acceptance'. The Ryff model of PWB has been internationally agreed and widely used in psychological studies.

*'Life satisfaction'*

Over many years, 'life satisfaction' or 'satisfaction with life' has been widely used in social gerontology to assess successful ageing (Neugarten et al., 1961). Life satisfaction, as one of the most heavily analysed concepts of subjective well-being, might be "the oldest, most persistently investigated issue in the social scientific study of aging" (Maddox & Wiley, 1976, p. 15). Diener (1984) defined life satisfaction as an overall assessment of feelings and attitudes (negative to positive) about one's life at a particular time point. However, an individual might judge their life satisfaction questions differently based on whether they think important things in life meet their expectations. Social relationships, health, wealth, source of education, liberty, moral values and personality traits are all potential sources of life satisfaction (Prasoon & Chaturvedi, 2016).

*'Quality of life'*

WHO (1998) defines 'quality of life' (QoL)' as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns". The term QoL was introduced in the 1960s from the Report of the President's Commission on National Goals (1960) in the United States aimed at concerns about social inequalities (Schuessler & Fisher, 1985). The wide use of QoL in health research is used to assess the outcome of healthcare interventions (Institute of Medicine, 1989). A practical example of QoL application in healthcare is the quality-adjusted life year (QALY) – a measure of "the state of health of a person or group in which the benefits, in terms of length of life, are adjusted to reflect the quality of life" (NICE Glossary, 2019). One QALY equals one year of life in perfect health.

*'Happiness'*

Very similar to 'life satisfaction', 'happiness' also encompasses a primary concept of subjective well-being. However, 'life satisfaction' refers to a cognitive evaluation aspect, and 'happiness' refers to an experience aspect of subjective well-being. Despite this distinction, happiness and life satisfaction measures in research still yield very similar results (Dolan & Metcalfe, 2012).

### 2.3.2 THE RELATIONSHIP BETWEEN MENTAL WELL-BEING AND MENTAL ILLNESS

The relationship between MWB and mental illness has been in a long debate based on the single and dual continuum models of mental health. The single continuum model suggests that the mental health continuum is a range that has MWB and mental illness at the two extreme ends (see Figure 4 below). An individual could lie at any point of the continuum and shift to another position when his situation changes. The single continuum model sits on a linear correlation perspective and can be used to predict an individual's mental health state over time. An example of measures of MWB that sits in this single continuum framework is the Warwick-Edinburgh Mental Well-being Scale (WEMWBS). The WEMWBS comprises 14-item about individual's feelings and thoughts over the previous two weeks and providing information on positive affects, interpersonal relationships, psychological functioning, cognitive health, and covering both the hedonic and eudemonic perspectives of MWB (Tennant et al., 2007). Study using WEMWBS demonstrates that there is a high negative correlation between mental illness (depression) and MWB (Stewart-Brown, 2017). Despite this, this negative correlation between WEMWBS and mental illness has not been confirmed with evidence on the older population.

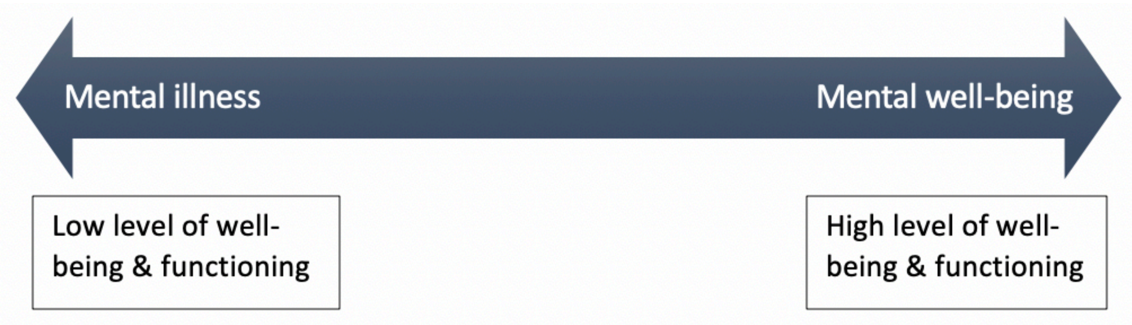



*Figure 4. Single Continuum Model of Mental Health*

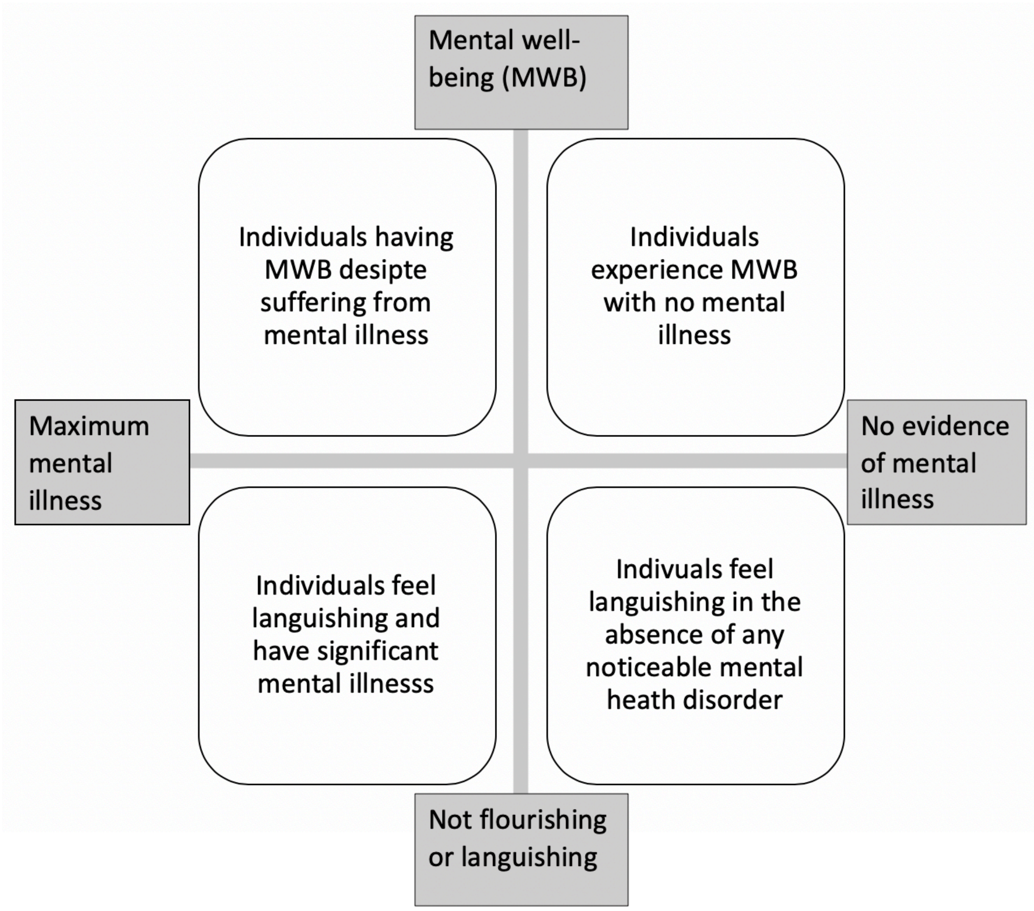



*Figure 5.Dual Continuum Model of Mental Health*

On the other hand, the dual continuum model suggests that MWB and mental illness are not necessarily two opposite ends of a single continuum (see Figure 5 above). Mental illness does not mean the absence of MWB. It implies that the individuals lie at the negative end of the continuum at present. People may have MWB while suffering from mental illness at the same time (Keyes, 2005; Weich et al., 2011; Westerhof & Keyes, 2010). An example of measures of MWB that sits in this dual continuum framework is the Mental Health Continuum-Short Form (MHC-SF) (Keyes et al., 2008; Lamers et al., 2011). The MHC-SF comprises 14 items that focus on positive aspects and measure emotional, psychological, and social well-being (Keyes, 2006; Keyes et al., 2008). Westerhof & Keyes (2010) demonstrated that older people who had less mental ill health did not score more highly on all three MWB domains. Compared to younger people, older people experienced more emotional well-being, similar levels of social well-being and slightly lower psychological well-being. However, this correlation does not hold for the oldest-old age group – aged 70 above by their definition. In this thesis, I undertook a single continuum model to test whether the negative correlation between MWB and mental illness would hold in older people. Adjusted analysis that controlled for previous MWB and other covariate (i.e. physical health and socio-demographic circumstances) was also undertaken (Chapter 7).

### 2.3.3 THE RELATIONSHIP BETWEEN MENTAL WELL-BEING AND PHYSICAL HEALTH

Health is a holistic concept that implies the interaction and integration of physical, mental, social and spirit (Stewart-Brown, 2018a; Hooyman & Kiyak, 2011). Physical and mental health are closely and complexly interconnected (Prince et al., 2007). Evidence suggests that at least 30% of people with long-term physical conditions also have a mental health problem (Cimpean & Drake, 2011). Previous study has reviewed and summarised the evidence of the link between MWB and physical health, with particular attention to physical health outcomes of chronic conditions, mortality, and morbidity (Hernandez et al., 2017).

People with chronic physical conditions are at risk of developing poor mental health, and vice versa. Some studies demonstrated that MWB is associated with the incidence of chronic illness, however, the evidence is inconsistent (Okely & Gale, 2016; Nabi et al., 2008). Diener & Chan (2011) argued that the association between MWB and the incidence of disease is likely to vary across different types of diseases due to the different physiological processes and causes that involved. Numerous studies have demonstrated that MWB is associated with increased longevity (longer survival/lower mortality) independently from the effect of negative constructs. Chida & Steptoe (2008) conducted a review of studies focused on the healthy population and studies focused on population with chronic diseases. They indicated that MWB (positive psychological well-being) was associated with reduced mortality in both healthy population (hazard ration (HR)=0.82) and diseased population (HR=0.98), with the effect size smaller in the latter population. Keyes & Simoes (2012) found out that the absence of MWB (flourishing) is associated with a 62% increase of mortality rate over ten years follow-up adjusting for age, gender, ethnicity, smoking, level of physical inactivity, and chronic diseases/conditions (CVD, cancer, stroke, HIV/AIDS). Empirical studies also demonstrated a longitudinal and bidirectional association between physical activity and MWB in younger adults (Vella et al., 2017) and also in older people (Steinmo et al., 2014). Older people are more likely to experience a decrease in physical activity due to frailty (Fried, 2016; da Silva, 2019). Frailty, a clinical state of increased vulnerability to poor resolution of homeostasis is common among older people and increases the risk of adverse outcomes including falls, delirium, disability and death (Clegg et al., 2013). The commonly used measure of frail is the Fried criteria which focuses mainly on the physical components associated with frailty: unintentional weight loss, self-reported exhaustion, weakness, slow walking speed and low physical activity (Fried et al., 2001). Frail individuals often have problems with mobility or other activities of daily living (ADL) or instrumental activities of daily living (IADL) (Gale et al., 2015). Nonetheless, frailty is preventable and reversible. Vigorous activity could significantly reduce the trajectory of frailty progression in a non-frail population (Rogers, 2017) while physical and nutrition interventions could reverse the frail condition among older adults (Ng, 2015; O’Connell, 2020). Moreover, physical activity could even compensate for the mortality risk associated with frailty in old age (Higueras‐Fresnillo et al., 2018).

The overall aim of this PhD research is to discover whether MWB influences outcomes associated with ageing and how it is associated with ageing well. Although the association between physical health and MWB has been discussed above, little is known about the potential pathways through which physical health affects MWB and vice versa. This PhD intended to undertake a different approach to proposing a mediation and moderation framework and estimating the mediation and moderation effects of MWB on the association between physical health and physically ageing well. Physically ageing well comprises good physical health and functional status that could cope with age related physical impairment. Comparing older people with the same level of physical health, whether higher MWB is associated with higher physically ageing well is also discussed (chapter 7).

### 2.3.4 'MEASURING NATIONAL WELL-BEING' IN THE UK

The UK's 'Measuring National Well-being Programme' was launched in 2010 based at the Office for National Statistics (ONS). The programme aims to develop 'accepted and trusted measures' of national well-being – understanding how the UK is doing as a whole rather than in its economic growth (e.g. GDP). It describes well-being as "'how we are doing' as individuals, as communities and as a nation, and how sustainable this is for the future" (ONS, 2018).

Initially, personal well-being was measured using four survey questions: evaluating whether individuals are satisfied with their lives overall, asking whether they have meaning and purpose in their lives, and asking their positive and negative emotions (separate questions) during a particular period. An example of the four measures of personal well-being questions in the ‘Measuring National Well-being programme’ is presented below in Table 2 (ONS). In 2013, A ‘population mental well-being’ measurement using the Warwick-Edinburgh Mental Well-being Scale (WEMWBS) (Tennant et al., 2007) was added to the personal well-being domain in order to provide a more holistic view of personal well-being. WEMWBS was developed to enable "the monitoring of mental wellbeing in the general population and the evaluation of projects, programmes and policies which aim to improve mental wellbeing" (Stewart-Brown, 2018b).

*Table 2.Personal well-being questions in 'Measuring National Well-being Programme' (Data Source: ONS)*

**Next I would like to ask you four questions about your feelings on aspects of your life. There are no right or wrong answers. For each of these questions I’d like you to give an answer on a scale of 0 to 10, where 0 is “not at all” and 10 is “completely”.**

| **Measure** | **Question** |
|---|---|
| Life Satisfaction | Overall, how satisfied are you with your life nowadays? |
| Worthwhile | Overall, to what extent do you feel that the things you do in your life are worthwhile? |
| Happiness | Overall, how happy did you feel yesterday? |
| Anxiety | On a scale where 0 is “not at all anxious” and 10 is “completely anxious”, overall, how anxious did you feel yesterday? |

## 2.4 A PARADOX OF AGEING AND MENTAL WELL-BEING

Previous empirical research has been primarily focused on the age-MWB association across the entire lifespan, with opinion varying as to whether this is best represented as ‘U-shaped' or ‘S-shaped' (visually ‘-shaped’). This chapter intends to provide an overview of the previous studies regarding the distribution of MWB in old age. Chapter

6 will provide a descriptive analysis of the distribution of MWB (measured by WEMWBS) using the Health Survey for England 2010-2016 datasets.

### 2.4.1 'U-SHAPED'?

A large body of literature has emerged on the association between age and mental well-being in the past few years. However, both theoretical and empirical evidence varies among disciplines, across economics and psychology (Wunder et al., 2009; LÓpez Ulloa et al., 2013). The empirical economic literature has been strongly influenced by the studies of Blanchflower and Oswald (2004, 2008), which found a statistically significant U-shape (convex) of mental well-being (measured by happiness and depression in their studies) by age with a minimum at middle age. This U-shape relation has been replicated and supported by a number of authors (Clark, 2007; Lang et al., 2011; McAdams et al., 2012). However, if we explore the end of this U-shape curve in more detail, we might find many variations. The assumptions made by the U-shape pattern might not apply to the oldest age group (Allen, 2008) since the cohorts' differences between younger-old (<75) and older-old (>=75) age groups had not been taken into account. Whether the observed pattern could be due to cohorts and/or time effects or simply saying whether the difference in MWB might be due to the different circumstances in which people born in different years were growing up is unclear (Van Landeghem, 2012). At this stage, knowledge is not sufficient to infer a conclusion, micro-level scoping in older people's MWB in distribution is needed. Nonetheless, the empirical economic evidence on the objective measure of MWB lacks psychological understanding and theoretical support. The results found in economic literature using different measures of MWB from the original definition that covering both the hedonic and eudemonic well-being. Blanchflower and Oswald (2008) used antidepressant consumption as an indirect objective measure of mental well-being and summarised the finding of inverted U-shape curve of antidepressant usage that peaks in people's late 40s as consistent support for the U-shape lifecycle of well-being. However, WHO (2005) distinguished the positive concept of MWB from the negative concept of the absence of mental illness or impairment in its definition of mental health. MWB by its definition is not merely the absence of disease but comprises both positive feelings (hedonic well-being) and positive functioning (eudaimonic well-being) (Stewart-Brown, 2015, 2018; Tennant et al., 2007; Bech et al., 2003). From the psychology literature, contrary to the economic literature finding, Mroczek and Spiro (2005) found an inverted U-shaped over later adulthood with a peak around the age of 65. Their study of approximately 2000 males aged 40+ from the Veterans Affairs Normative Ageing Study was "one of the first panel analyses to explore the relationship between ageing and reported well-being measured by positive affect" (LÓpez Ulloa et al., 2013, p. 237).

### 2.4.2 'S-SHAPED'?

Recent research indicates a revisionary S-shape age-MWB pattern across the lifetime (Fischer, 2009; Bauer, 2017). Cross-country evidence confirmed rather than contradicted the U-shape before late adulthood (Van Landeghem, 2012; Schwandt, 2015) and pointed to a three-phase pattern with a second turning point in life at very old ages (Wunder *et al.*, 2009; Gwozdz & Sousa-Poza, 2010). Tampubolon (2015) also confirmed this inverted U-shape pattern in later life in his recent study and indicated curvilinear age trajectories of quality of life at an advanced age (aged 50+) with a peak at 67 years. The ONS (2016) cross-sectional study further reported a modified U-shape in personal well-being across the life-time and suggested that positive well-being is convex across life-time but concave at old age. In the UK, people aged 65 to 79 reported the highest average levels of well-being while those aged 45 to 54 reported the lowest. Average anxiety increased through early and middle adulthood and peaked around age 45 to 59, falling steeply afterwards and then remaining relatively flat for those aged 65+. On the other hand, positive well-being increased from early 50s and fell in the oldest old groups (age 75+) with the highest drop in "feelings of activities they do in life are worthwhile" (see Figure 6 below).

The four personal well-being questions are:

Overall, how satisfied are you with your life nowadays?

Overall, to what extent do you feel the things you do in your life are worthwhile?

Overall, how happy did you feel yesterday?

Overall, how anxious did you feel yesterday?

**People are asked to respond on a scale of 0 to 10, where 0 is "not at all" and 10 is "completely"**

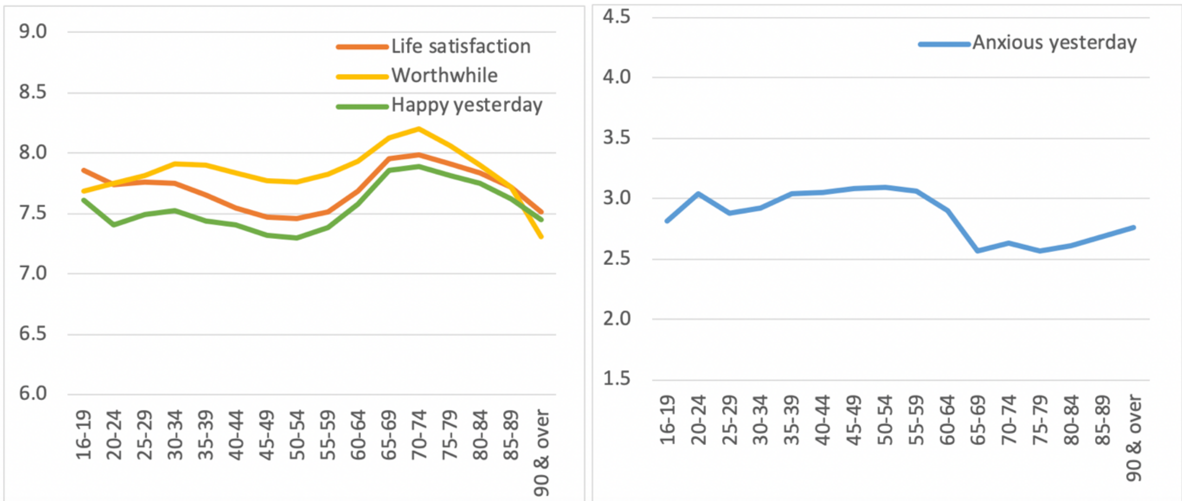



*Figure 6. Personal well-being by age group (Data Source: Office for National Statistics, Annual Population Survey 2016)*

Despite that the S-shaped distribution is only found in papers that include older age bands, the finding from the Annual Population Survey also supported the psychology theory that MWB is more than just the absence of mental illness. Other factors might have an impact on it, especially in later life. The overall aim of this PhD research is to discover whether MWB influences outcomes associated with ageing and how it is associated with ageing well. It intends to describe the distribution of MWB in old age, explore the association between old age risk factors (determinants) and MWB, and examine the consequences of MWB in community-dwelling older people. A descriptive analysis of the distribution of MWB using the Health Survey for England (HSE) 2010-2016 datasets will be presented in Chapter 6. The previous studies on the factors related to MWB and consequences of MWB will be systematically reviewed in Chapters 4 and 5 successively. Quantitative analysis of the determinants and consequences of MWB using the UK Household Longitudinal Study (UKHLS) 2009-2017 datasets will be presented in Chapter 7.

## 2.5 RESEARCH BACKGROUND – HEALTHCARE BURDEN IN THE UK

According to the ONS, older people are the largest and fastest-growing demographic in the UK. The latest estimates from ONS showed that there were 11.8 million UK residents (18% of the population) aged 65+ in 2016 (ONS, 2017). Over the past 40 years, the proportion of children (under 16) in the UK population declined from 24.5% to 18.9% between 1976 and 2016 and is projected to decline even further in future years. On the other hand, the proportion of people aged 65+ increased from 14.2% to 18% between 1976 and 2016 and is projected to continue to grow to a quarter of the population by 2046 (see Figure 7 below).

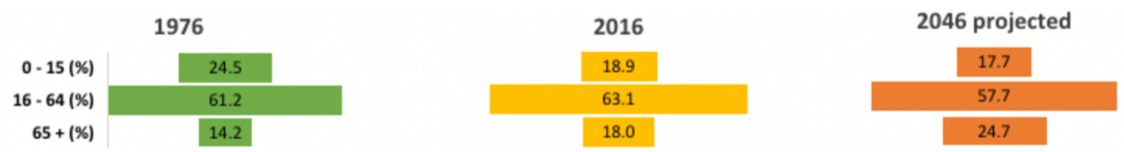



*Figure 7. Age distribution of the UK population, 1976 to 2046 (projected) (Data Source: ONS, 2017)*

Moreover, as the life expectancy in the UK has been steadily increasing over the last few decades and is projected to continue increasing, the proportion of the population aged 85+ is projected to increase steeply (see Figure 8 below).

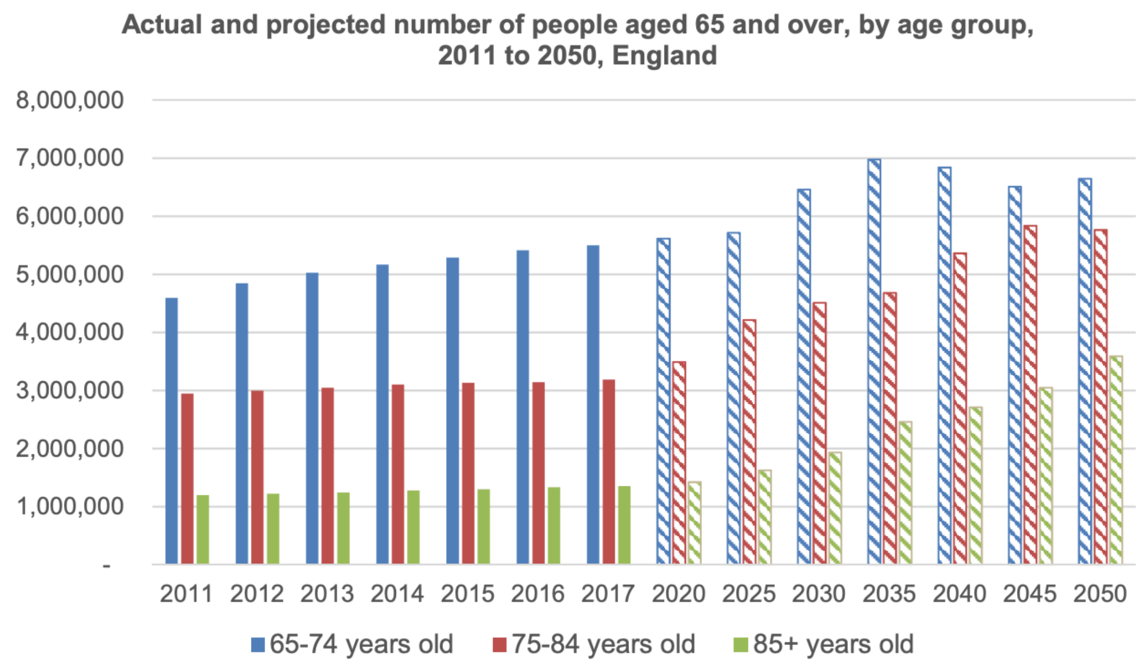



*Figure 8. Size of each population at each census year from 2011 - 2017and population projection forecast 2020 - 2050 (Adapted from. ageUK, 2019, p8 Source: ONS, Analysis of population estimates tool; Mid-Year Estimates 2011-2017 among those 65+)*

In view of the rising numbers of older people, the well-being of this group is of growing importance. Recent studies have been focused more on the potential problems of old age, the financial impact on society and the crisis of care provision (Knickman & Snell, 2002; Wittenberg et al., 2001; Pickard, 2015). According to the Policy Exchange, a think tank researching in 2010: 1.5 million people aged 65+ will need care and support by 2025. The increasing proportion of the older population compared to the rest of the population places extreme pressure on financing the health care and support system.

Consequently, the government's expenditure on elderly care could increase by 50% over the next 15 years, from £16.17 billion to £24.26 billion at 2008-09 prices (Featherstone and Whitham, 2010). The 'standstill gap' in funding is estimated to be at £1.5 billion per year by 2020/21 and increase to £6.1 billion by 2030/31 (ageUK, 2019). Care and support have never been free. Many older people and disabled people can face "catastrophic and potentially ruinous bills" for their care and support under the current healthcare funding system (Department of Health, 2014). However, these predictions are all based on average results among the current, old population. Promoting mental well-being and positive ageing that helps older people identify their role, be more active and engage more in society might help them cope better with later life challenges, preventing them from social isolation and giving them positive contribution opportunities. From a cost-effectiveness point of view, improving mental well-being could lead to the possibility of reducing risk to health by improving physical well-being as well as reducing risk to cost by reducing the needs of care.

# CHAPTER 3 METHODOLOGY AND JUSTIFICATION

## 3.1 INTRODUCTION

In this chapter, I explain how my research fills the gaps in current knowledge of mental well-being (MWB) in old age. Firstly, I describe the aims, research questions and hypotheses for conducting my research on MWB in old age. Secondly, I summarise the commonly used scales that measure aspects of well-being and ageing well. Finally, I explain the research design and methodology developed to achieve the research aims at each phase: preliminary, quantitative analysis and integration. In addition, I also justify the chosen analytic methods and approaches used in conducting my research. The specific methods at each phase are described in more detail in the methods section of later chapters (4-7).

As mentioned in the previous chapter (Chapter 2: Background), there are several commonly and interchangeably used terms of well-being: mental well-being (MWB), psychological well-being, life satisfaction, quality of life and happiness. Moreover, different academic disciplines (philosophy, psychology and social science) have been involved in debates about the definition of well-being (Stewart-Brown, 2017, p. 215). In this thesis I used the original definition of MWB from Stewart-Brown (2015, 2018) as comprising both positive feelings (hedonic well-being) and positive functioning (eudaimonic well-being). From the different aspects of well-being these disciplines have focused on, several measures of well-being have been developed. In this chapter, I summarise and review some commonly used scales that measure similar aspects of MWB including emotion (positive affect, happiness and satisfaction with life), cognition (cognitive health and positive psychological functioning), social functioning (relations with others and society), coherence (sense of meaning and purpose in life) and vitality.

The overall aim of this PhD is to discover whether MWB is associated with ageing well. As also mentioned in the previous chapter, the term 'ageing well' is often interchangeably used with 'healthy ageing', 'flourishing' and 'successful ageing'. Ageing well is defined in this PhD as a state of doing, living and functioning well physically, psychologically and socially. In this chapter, I also review some commonly used measures that comprise these three perspectives of ageing well. Since MWB is an indicator of psychological wellness, a more robust analysis of whether MWB could affect physical wellness is undertaken in Chapter 7.

## 3.2 RESEARCH QUESTIONS

### 3.2.1 RESEARCH AIMS

The overall aim of this PhD research is to discover whether mental well-being (MWB) influences outcomes associated with ageing and how it is associated with ageing well. By doing this, I hope to attract policy attention to promoting MWB in older people. There are also three sub aims:

1. Describing the distribution of MWB in order to identify the variations in MWB distribution and generate testable hypotheses on further research on the model of MWB (proposed in Chapter 7 methods) in old age;
2. Investigating the aetiological factors associated with older people's MWB (determinants), by which I hope to learn how to improve MWB in old age. This

engages a particular focus on the multifactorial associations between MWB and its determinants, including the dominant determinants of MWB; and

3. Exploring the importance of maintaining a high level of MWB on ageing well (consequences). This will focus on whether MWB demonstrates a significant enhancing effect on physical wellness; and whether MWB mediates and/or moderates the association between physical health and physically ageing well.

### 3.2.2 RESEARCH QUESTIONS

The main research questions addressed in this PhD attend to the epidemiology of MWB in later life, from its distribution to its determinants and consequences. The focus population is community-dwelling older people in the UK. The mechanisms behind the research questions referring to an MWB cycle in decision making. Figure 9 summarises the epidemiology of MWB and shows the determinants of MWB and the essential mechanisms through which enhancing MWB toward age can impact on the consequences of MWB.

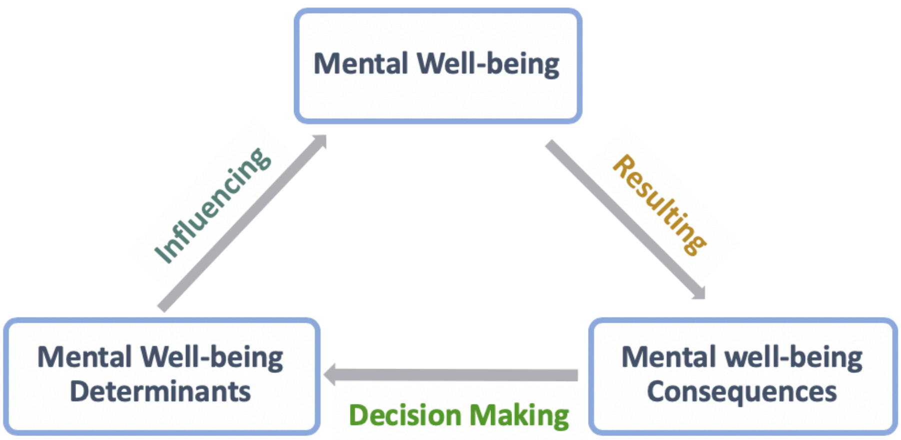



*Figure 9. Epidemiology of MWB*

The research also addresses the following inter-related questions:

Research Question 1: How much variation is there in the distribution of MWB among older people, and in particular how does MWB vary with age?

Research Question 2: What are the determinants of MWB in old age and to what extent do they explain the variations in MWB?

Research Question 3: To what extent does MWB directly affect physically ageing well? (Note: Physically ageing well is measured by a good physical health and functional status that could cope with age related physical impairment)

Research Question 4: Does MWB mediate and/or moderate the association between physical health and physically ageing well?

### 3.2.3 RESEARCH HYPOTHESES

The overall hypothesis tested in this PhD is that older people's MWB not only has a direct influence on the ageing well process, but also has an indirect influence where MWB mediates and modifies the effect of other later-life risk factors on the ageing well processes (see Figure 10 below). In addition, the theoretical literature on the age and MWB paradox across life course suggest either a U-shape (Blanchflower & Oswald 2004, 2008) or a revisionary S-shape (Fischer, 2009; Bauer, 2017); however, MWB has more variations in its distribution in old age (Allen, 2008).

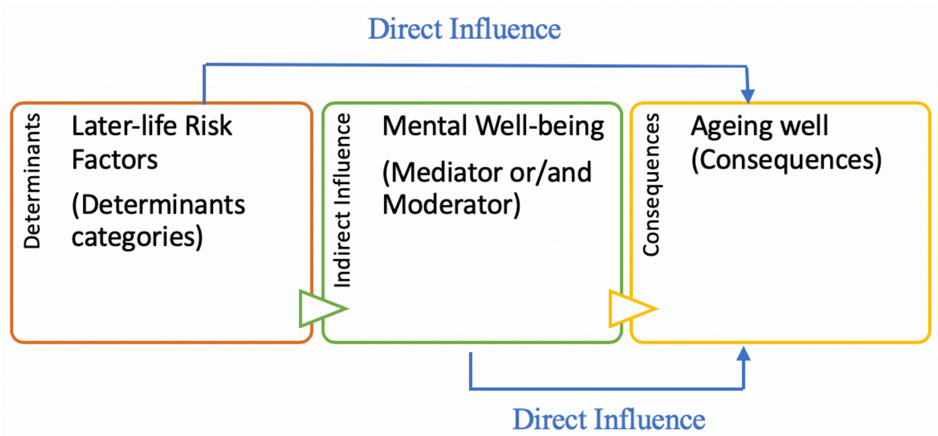



*Figure 10.Overall hypotheses*

The other hypotheses included in this PhD are:

1) MWB in old age is neither a unidirectional increase nor decrease. Variations in distribution will be found. Using smaller age bands is more suitable when analysing older people's MWB;
2) Later-life risk factors will jointly associate with MWB, of which ill health (physical and mental) dominates the negative effects of later-life risk factors on MWB;
3) MWB will promote ageing well not only through enhancing psychological wellness but also through enhancing physical wellness. Higher MWB predicts better physically ageing well even after controlling for other later life risk factors;
4) MWB will mediate the association between physical health and ageing well. Higher MWB reduces the negative effect of physical health (indirectly) on physically ageing well; and
5) MWB will moderate the association between physical health and ageing well. Comparing people with the same level of physical health, having higher MWB predicts better physically ageing well.

### 3.2.4 RESEARCH GAPS AND RATIONALE

Older people are the largest and fastest-growing demographic in the UK. This increasing size of the older population may lead to increases in health and social care costs and expenditure on pensions, which places extreme pressure on financing the healthcare and support system. Ageing well is crucial because it has links not only to reducing health risks but also to reducing the cost of ill health. The absence of physical illness is a common criterion for ageing well; however, it is also vital that older people are enabled to maintain their MWB.

Although we know a lot about illness, we don't know as much about wellness. The current research on MWB lacks integrated evidence on the distribution, determinants and consequences of MWB among older people in one study. Previously, no reviews have tried to synthesise evidence of multifactorial influences on older people's MWB with the exception of a rapid review targeted on the oldest old population aged 80 and over (Cresswell-Smith et al, 2019). Nonetheless, there is no review on the consequences of MWB on ageing well. This PhD therefore will start with two parallel systematic reviews of existing literature on the factors related to older people's MWB and the consequences of MWB in old age.

In addition, the multifactorial association between MWB and its determinants has rarely been examined in a single study. Hence the cumulative effects of these determinants on MWB remain uncertain. Moreover, there is a dearth of research on MWB consequences in old age included going beyond the associations with mortality. On top of that, the current gap in our knowledge of MWB is whether MWB could mediate and/or moderate the association between later-life risk factors and ageing well. In this PhD, I will describe the distribution of MWB and provide integrated quantitative evidence on the determinants and consequences of MWB drawing on two large, UK national representative survey datasets to identify and quantify the model of MWB in old age. The datasets this PhD will use are the Health Survey for England (HSE) 2010-2016 and 'Understanding Society'- the UK household longitudinal study (UKHLS) 2009-2017. This PhD thesis is the first research to link the distribution, determinants and consequences of MWB among older people. It could add value to the knowledge of MWB and how to promote MWB in later life.

## 3.3 VALIDITY, RELIABILITY AND JUSTIFICATION OF MEASURES USED IN THIS THESIS

### 3.3.1 SCALES THAT MEASURE SIMILAR ASPECTS OF MWB

This thesis does not engage in debates about MWB definitions but instead defines it as comprising both positive functioning (eudaimonic well-being) and positive feelings (hedonic well-being) (Stewart-Brown, 2015, 2018). Figure 11 lists common measures of well-being under these two well-being conceptual perspectives. The hedonic perspective of well-being reflects on the emotional well-being in research and measures the positive affect, happiness and satisfaction with life. Common well-being measures under the hedonic perspective that have been used in measuring older people's MWB are the Positive and Negative Affect Schedule (PANAS-SF) (Watson, Clark, & Tellegen, 1988), Bradburn's Affect Balance Scale (ABS) (Bradburn, 1969), WHO-5 Well-being Index (WHO, 1988), Satisfaction with Life Scale (SWLS) (Diener et al., 1985), Life Satisfaction Index: A (LSIA) (Neugarten, Havighurst & Tobin, 1961), Scale of Positive and Negative Experience (SPANE) (Diener et al., 2009), and other single item happiness or life satisfaction scales. The contents and scoring systems of each well-being measures are outlined in Appendix A – Measures and scoring system.

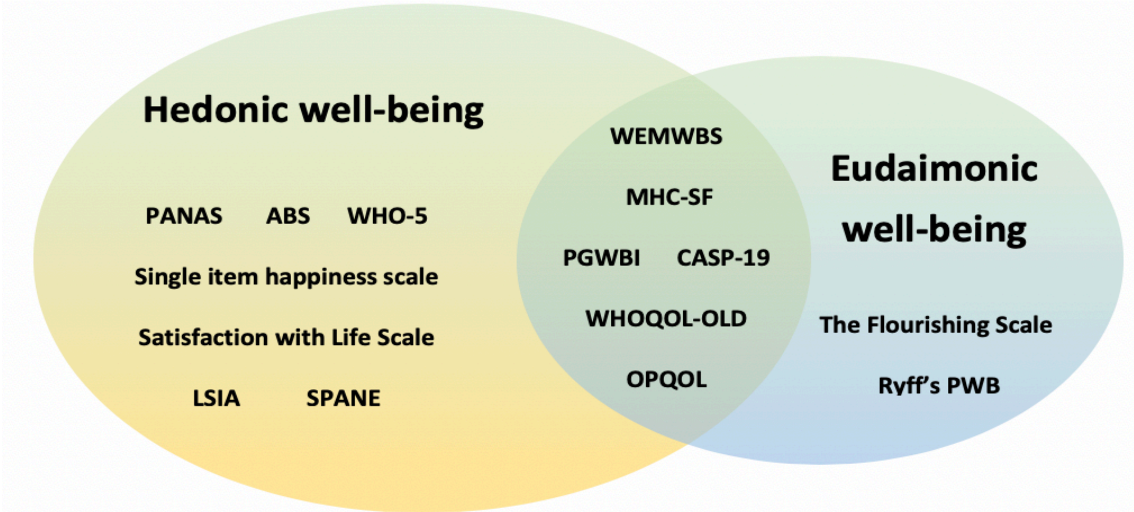



*Figure 11. Scales by well-being conceptual perspectives*

The eudaimonic view of well-being highlights psychological and social well-being, in the form of purpose, integration, contribution, autonomy, intimacy, acceptance, and mastery (Keyes & Simoes, 2012). Ryff's psychological well-being scale (Ryff's PWB) (Ryff, 1989, 1995; Ryff & Keyes, 1995) is designed to measure six theoretically motivated constructs of psychological wellbeing including: autonomy comprises independence and self-determination; environmental mastery that refers to the ability to manage one's life; personal growth that refers to the ability to open to new experiences; positive relations with others indicating having satisfied, high quality relationships; purpose in life that believing one's life is meaningful; and self-acceptance indicting having a positive attitude towards oneself and one's past life. The Flourishing Scale (Diener et al., 2009) is an 8-item scale that provides a single psychological well-being score. It based on the theories of psychological and social well-being and measures respondent's self-perceived success in relationships, self-esteem, purpose and optimism.

The intersection in Figure 11 represents MWB that defined in this PhD – include both eudaimonic and hedonic aspects of well-being. Common well-being measures under both the hedonic and eudaimonic perspective that have been used in measuring older people's MWB are the Warwick-Edinburgh Mental Well-being Scale (WEMWBS) (Tennant et al., 2007), Mental Health Continuum-Short Form (MHC-SF) (Keyes et al., 2008), the Psychological General Well-Being Index (PGWBI) (Dupuy, 1984), CASP-19 (Hyde et al., 2003), WHOQOL-OLD (WHO, 2006b), and the Older People's Quality of Life Questionnaire (OPQOL) (Bowling, 2009). The contents and scoring systems of each well-being measures are outlined in Appendix A – Measures and scoring system.

The analyses undertaken in this PhD are based on secondary analysis of data collected as part of two large UK survey datasets. MWB was measured by the Warwick-Edinburgh Mental Well-being Scale (WEMWBS) – used in the Health Survey England (HSE) and the Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) – used in the UK Household Longitudinal Study (UKHLS), also known as Understanding Society. Table 3 below also summarises and reviews some commonly used scales that measure similar aspects of MWB to demonstrate an awareness of other measures rather than the WEMWBS. The summary table covers emotion (positive affect, happiness and satisfaction with life), cognition (cognitive health and positive psychological functioning), social functioning (relations with others and society), coherence (sense of meaning and purpose in life) and vitality aspects. The scales are separated into three dimensions, namely well-being (or subjective well-being) dimensions, subjective health dimensions and quality of life dimensions (Stewart-Brown, 2017; Bowling, 2017). The scoring forms of each scale are also presented in Appendix A - Measures and scoring system.

*Table 3.Scales that measure similar aspects of MWB*

| Measures | Positive affect | Happiness | Satisfaction with life | Psychological functioning | Interpersonal relationship | Purpose in life | Vitality | Cognitive health |
|---|---|---|---|---|---|---|---|---|
| **Well-being dimensions:** | | | | | | | | |
| **WEMWBS** | ++ | ++ | | ++ | ++ | | ++ | ++ |
| **The Flourishing Scale** | | | | ++ | ++ | ++ | ++ | |
| **MHC-SF** | + | ++ | ++ | ++ | ++ | ++ | | |
| **Ryff's PWB** | | | | ++ | ++ | ++ | | |
| **PGWBI** | ++ | ++ | ++ | ++ | | | ++ | |
| **WHO-5 well-being index** | ++ | | | | | | | |
| **PANAS** | ++ | | | | | | | |
| **ABS** | ++ | + | + | | | | | |
| **SPANE** | ++ | ++ | | | | | | |
| **Single item happiness scale** | | ++ | | | | | | |
| **Satisfaction with Life Scale** | | | ++ | | | | | |
| **LSIA** | ++ | ++ | ++ | | | + | | |
| **Subjective health dimensions:** | | | | | | | | |
| **SF-12 MCS** | ++ | | | + | + | | ++ | |
| **Quality of life dimensions:** | | | | | | | | |
| **CASP-19** | ++ | ++ | ++ | ++ | + | ++ | ++ | |
| **OPQOL** | + | ++ | ++ | ++ | ++ | | + | |
| **WHOQOL-OLD** | | ++ | ++ | ++ | ++ | | + | |

Note: **++** indicated measuring an MWB aspect, **+** indicated somewhat partially measuring an MWB aspect.

**WEMWBS**: The Warwick-Edinburgh Mental Well-being Scale; **MHC-SF**: Mental Health Continuum Short Form; **Ryff's PWB**: Ryff's Psychological Well-Being Scales; **PGWBI**: The Psychological General Well-Being Index; **PANAS**: Positive and Negative Affect Schedule; **ABS**: Bradburn's Affect Balance Scale; **SPANE**: Scale of Positive and Negative Experience; **LSIA**: Life Satisfaction Index-A; **SF-12 MCS:** The 12-item short form health survey - mental health composite scores; **OPQOL**: Older People's Quality of Life; **WHOQOL-OLD**: World Health Organization Quality of Life – old

### 3.3.2 VALIDITY AND RELIABILITY

Validity aims to assess the instruments on what they are supposed to measure and whether they perform as they are designed to perform. The WEMWBS was developed from both a hedonic and eudaimonic perspective as an instrument to monitor positive mental well-being at a population level (Stewart-Brown, 2017). As recommended by the Department of Health (2014), WEMWBS is a valid and appropriate measure of mental well-being, and the findings could be used to measure changes over time among identified groups. It was tested initially within a student sample (n=348), and subsequently in two mini-focus groups in Scotland and England, and finally within a Scottish population sample (n=1749) (Tennant et al., 2007). It was found to be a validated measure of mental well-being with approved "high correlations with other mental health and well-being scales and lower correlations with scales measuring overall health" (Tennant et al., 2007, p. 1). The WEMWBS scores are recorded in *numerical* type on a scale of 14-70. The scores are based on individuals' responses to 14 positive statements (score 14 for those who answer 'rarely' to all questions while score 70 for those who answer 'all of the time'). The scores were nearly normal distributed with no ceiling effects in a population sample. The higher the score, the greater the individual's MWB. The SWEMWBS uses 7 of the WEMWBS's 14 items that covered more about the "functioning" aspect of MWB rather than "feelings". The scores are also recorded in *numerical* type but on a scale of 7-35. The SWEMWBS has been validated for the general population (Ng et al., 2017; Haver et al., 2015). Besides, Koushede et al. (2018) validated both the original WEMWBS and the SWEMWBS in Danish general population and compared the scores with scores representative of three other European setting, specifically Iceland, England (UK), and Catalonia (Spain). The WEMWBS/SWEMWBS showed its strength on high test-retest reliability with a comparable lower social desirability bias (Tennant et al., 2007). For this PhD, I have decided to use both WEMWBS (HSE) and SWEMWBS (UKHLS) to measure older people's mental well-being.

### 3.3.3 SCALES THAT MEASURE DIMENSIONS OF AGEING WELL

As mentioned in the last chapter (Chapter 2: Background), the phrase 'ageing well' is often interchangeably used with 'healthy ageing', 'flourishing' and 'successful ageing'. Similar to defining MWB, biological, psychological and sociological theories of ageing may jointly explain how ageing successfully or well could be enhanced. As a reminder, ageing well is defined in this PhD as a state of doing, living and functioning well physically, psychologically and socially. In this chapter, I also provide a table (see Table 4 below) that summarises and reviews some commonly used scales that measure these three dimensions of ageing well.

*Table 4.Scales that measure dimensions of ageing well*

| Measures | Physically ageing well | Psychologically ageing well | Socially ageing well |
|---|---|---|---|
| **SF-12 (PCS & MCS)** | ++(PCS) | ++(MCS) | +(MCS) |
| **EQ-5D** | ++ | | |
| **OPQOL** | ++ | ++ | ++ |
| **WHOQOL-OLD** | ++ | + | ++ |
| **CASP-19** | + | ++ | + |
| **PGWBI** | ++ | ++ | |
| **The Flourishing Scale** | + | ++ | ++ |
| **WEMWBS** | | ++ | + |

**Note: ++ indicates measuring an ageing well dimension, + indicates partially measuring an ageing well dimension.**

The analyses undertaken in this PhD are based on secondary analysis of data collected as part of two large UK survey datasets. Due to the data availability, ageing well was only assessed using the 12-item short form health survey (SF-12). The SF-12 includes 12 items covering 8 domains: general health, physical functioning, role functioning (physical), bodily pain, role functioning (emotional), mental health, vitality and social functioning (Ware et al., 1995, p. 11). The answers to the 12-item questions from the 8 domains are combined, scored and weighted to create two subscales (physical and mental health composite scores). A SF-12 algorithm has been made to compute aggregate scores of physical health composite scores (PCS) and mental health composite scores (MCS). The scores range from 0 to 100, where a zero score indicates the lowest level of health measured by the scales and 100 indicates the highest.

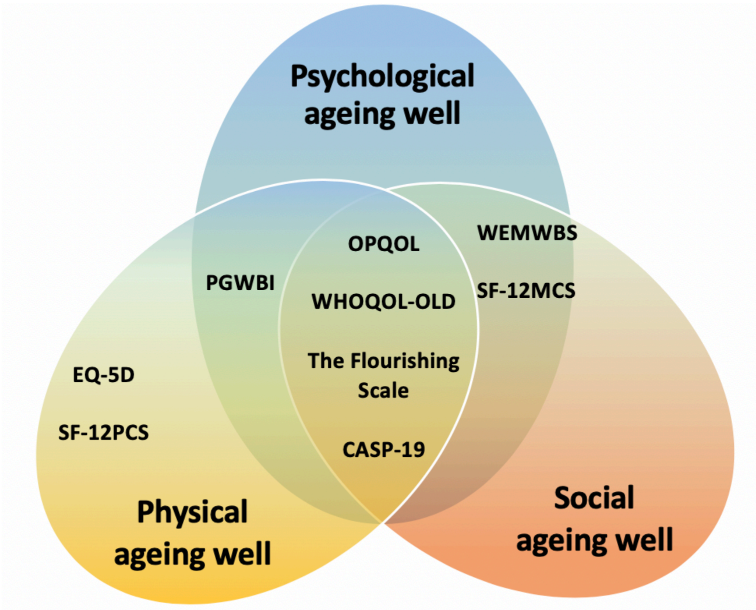



*Figure 12. Scales that measure dimensions of ageing well*

As seen in Figure 12 above, WEMWBS measures the dimensions of psychological and social ageing well. Hence, similar scales that also measure psychological and social dimensions were not used as MWB consequences of ageing well since there would be a circularity (or tautology) if MWB were both the exposure and part of the outcome. Besides, a more robust analysis that draws particular attention to whether MWB could affect physical wellness in the ageing process (physically ageing well) was undertaken. In other words, the analyses of MWB consequences in old age in this PhD thesis focused on the association between MWB and SF-12 PCS. This PhD thesis will add to the current knowledge of MWB consequences by providing evidence on whether MWB demonstrates a significant enhancing effect on physically ageing well. Moreover, whether

MWB mediates and/or modifies the association between physical health and physically ageing well will be explored.

## 3.4 METHODOLOGY AND JUSTIFICATION

### 3.4.1 RESEARCH STRATEGY

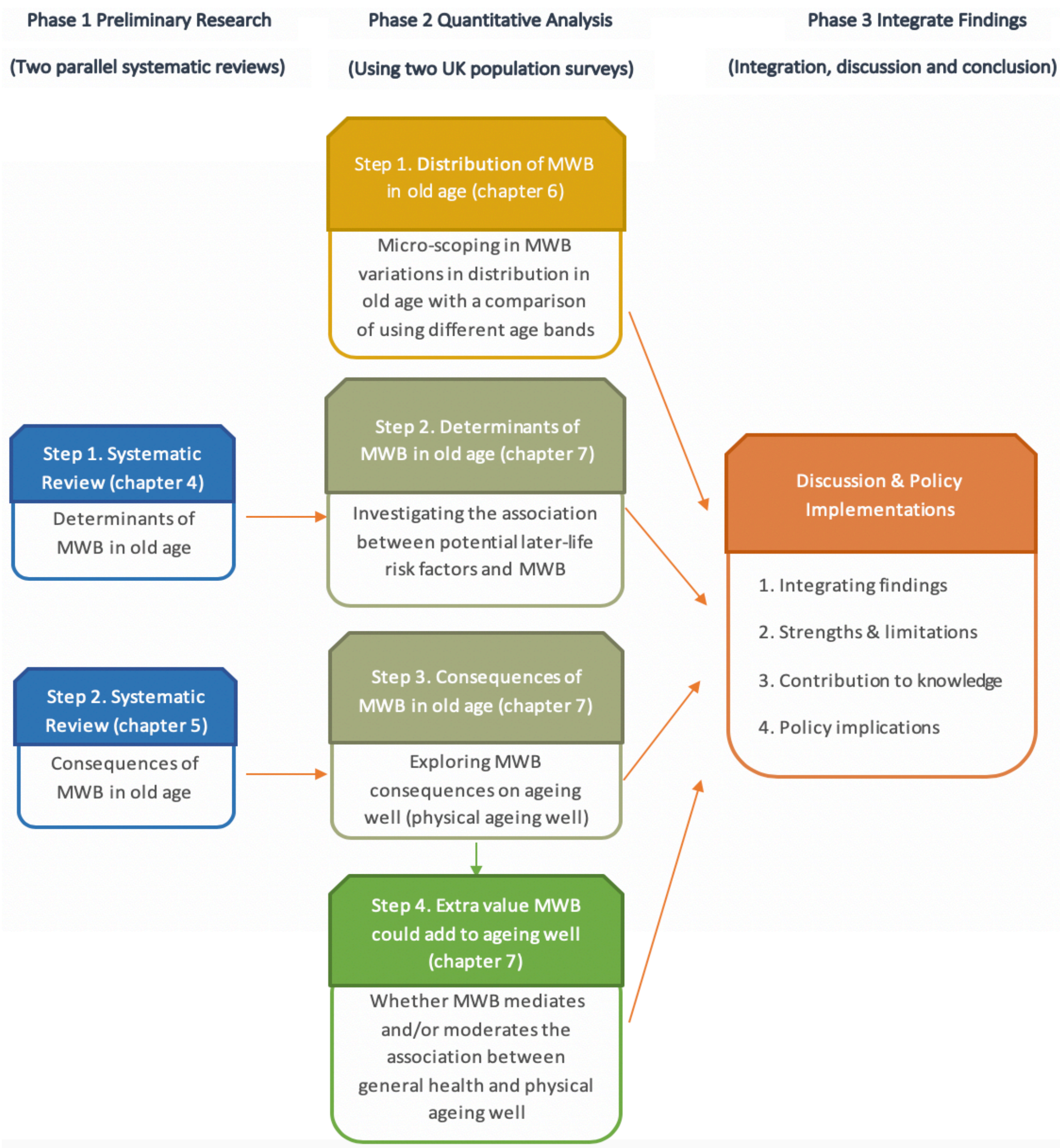



*Figure 13.Research strategy*

This PhD involves three phases (see Figure 13 above):

• Phase 1. Preliminary research (two parallel systematic reviews):

Step 1. (Chapter 4) A systematic review of existing literature on the association between later life risk factors and older people's MWB. Potential aetiological factors are separated into five categories: physical health and functioning; social functioning; behavioural and lifestyle; psychological; and demographic and socio-economic factors; and

Step 2. (Chapter 5) A systematic review of existing literature on the consequences of MWB in old age. Narrative quantitative analysis was undertaken to examine MWB consequences of reducing mortality.

• Phase 2. Quantitative analysis (using two large UK population survey datasets):

Step 1. (Chapter 6) Describing the distribution of older people's MWB and investigating variations in MWB in old age using the HSE 7-year datasets. Different age bands are used when analysing older people's MWB;

Step 2. (Chapter 7) Investigating the association between potential later life risk factors and older people's MWB using UKHLS 9-year datasets. The primary explanatory variables are derived from a previous systematic review (Chapter 4). Multiple regression analysis and multilevel modelling are used to examine the determinants of MWB in old age;

Step 3. (Chapter 7) Testing the association between MWB and ageing well (in particular, physically ageing well) using UKHLS 9-year datasets. Random-effects models are used to examine the association between MWB and its consequences on ageing well; and

Step 4. (Chapter 7) Examining whether MWB mediates and/or modifies the association between late life risk factors and ageing well using UKHLS 9-year datasets. The mediation effect of MWB is analysed using structural equation modelling (SEM). The moderation effect of MWB is examined using moderated multiple regression and robust logistic regression.

At this phase, a loss to follow-up analysis of UKHLS 9-year datasets is also performed. Cox proportional hazards regression and a Kaplan-Meier survival curve (K-M curve) are applied.

• Phase 3. (Chapter 8) Discussion and integration of findings with policy implications:

Discussion and integration findings with policy implications. Firstly, the research findings are integrated, summarized and discussed in terms of study aims and objectives and compared with existing literature of MWB in old age. Secondly, I focus on methodological issues of the study, its strengths and limitations. Finally, I discuss the contribution of this PhD in terms of policy implications. Areas of future research are also outlined.

### 3.4.2 STUDY POPULATION AND DATASETS DESCRIPTION

The study population in this PhD thesis is community-dwelling older people in the UK. Older people are defined as populations aged 60 or above according to the UN's use of old age (UN, 2001). The analyses undertaken in this PhD are based on secondary analysis of data collected as part of two large UK survey datasets: The Health Survey for England (HSE) and Understanding Society - the UK Household Longitudinal Study (UKHLS). Chapter 6 (the distribution of MWB in old age) uses HSE 2010-2016 7-year datasets, while Chapter 7 (the determinants and consequences of MWB in old age) uses UKHLS 2009-2017 9-year datasets.

*The Health Survey England (HSE)*

HSE is an annual survey of the general household population of England excluding people in institutions such as care homes. It is not a longitudinal survey, which means a fresh sample is interviewed each year in the survey. However, the HSE is considered to be a representative sample of repeated cross-sections of the population. The Health Survey for England 2010-2016 datasets are publicly available secondary datasets. Each of the 7-year of datasets were downloaded from the UK data service under project ID 168037. The UK data service series codes for the datasets were: HSE2010 (No. 6986), HSE2011 (No. 7260), HSE2012 (No. 7480), HSE2013 (No. 7649), HSE2014 (No. 7919), HSE2015 (No. 8280) and HSE2016 (No. 8334).

*Understanding Society - the UK Household Longitudinal Study (UKHLS)*

The UKHLS builds on the success of the British Household Panel Survey (BHPS). Longitudinal studies have advanced social science methods, enhanced the understanding of significant social changes, and supported a better assessment of policy interventions than cross-sectional data, which are based on only a single observation of the individual. As an advantage, households are also strictly observed in Understanding Society. For each responding household, information is collected using different types of questionnaires including: a household coversheet and questionnaire (one per household), an individual questionnaire (one per eligible adult, aged 16 and above), a proxy questionnaire for those individuals who are not present and give their permission for information to be collected on their behalf, an adult self-completion questionnaire (one per eligible adult) and a youth self-completion questionnaire (for youths aged 10-15 years).

The Understanding Society 2009-2017 datasets consist of 3 waves that measured population MWB using the Short Warwick-Edinburgh Mental Well-being (SWEMWBS): wave1 2009-2011, wave4 2012-2014, and wave7 2015-2017. Each of them is downloaded from the UK data service under project ID 168037. The UK data service series code is 6614 for the complete datasets "Understanding Society: Waves 1-8, 2009-2017 and Harmonised BHPS: Waves 1-18, 1991-2009". The analysis undertaken combines individual (substantive data for responding adults 16+, including proxies) datasets and household (information for all persons in the household, including children and non-respondents) datasets from each wave by a one-to-one match-merge of cross-wave person identifier (pidp).

### 3.4.3 PHASE 1. PRELIMINARY RESEARCH – TWO PARALLEL SYSTEMATIC REVIEWS

PRISMA (Moher et al. 2015) guidelines were used as a framework for systematic reviews. Prior to formulating the reviews, I conducted two scoping reviews to ensure that a systematic review or meta-analysis pertaining to the research questions had not been previously published or registered. The review protocols were registered on PROSPERO (Registration number: CRD42016048146 and CRD42016048147). Only one search strategy was designed for conducting the two parallel systematic reviews.

<u>Review questions:</u>

- Review 1: What is the evidence from the literature on the factors related to older people's MWB?
- Review 2: What is the evidence from the literature of MWB consequences on ageing well?

Review objectives:

The objectives of the two parallel systematic reviews were:

- Examine the factors related to older people's MWB and MWB consequences;
- Summarise and synthesise research findings;
- Identify research gaps and refine overall research question;
- Generate testable hypotheses for phase 2 quantitative analysis in a later chapter (Chapter 7).

Search strategy:

- The literature search databases I used include PubMed, Ovid MEDLINE, PsycINFO, Scopus and Cochrane Library.
- The search terms were {("Well Being" OR wellbeing OR "well-being" OR "positive mental health" OR "life satisfaction" OR "quality of life" OR happiness) AND (mental OR positive) AND (aging* OR ageing* OR "older people" OR "older adult*" OR pensioner* OR elderly OR geriatric* OR retired)} in Title/Abstract.
- The reference lists of the retrieved articles and review papers were searched and appraised to identify potentially relevant articles. I screened 100% of abstracts and full-text articles, and a second reviewer screened 50% of abstracts and full-text articles as a reliability check. Disagreement between reviewers was discussed until a final consensus was reached.

Quality assessment:

Quality assessment of the selected systematic review studies was performed to establish the validity of findings. Standardised approaches for rating the quality of the individual studies are presented, and the tools used in the quality assessment are set out in Table 5 below.

*Table 5. Summary of the quality assessment tools*

| Study Design | Quality Assessment Tool | Quality Rating of study |
|---|---|---|
| *Cross-Sectional* | Newcastle Ottawa Scale, NOS | Score 0-10<br>Selection (Max 5*)<br>Comparability (Max 2*)<br>Outcome (Max 3*) |
| *Cohort Study* | Newcastle Ottawa Scale, NOS | Score 0-9<br>Selection (Max 4*)<br>Comparability (Max 2*)<br>Outcome (Max 3*) |
| *Longitudinal Study* | Newcastle Ottawa Scale, NOS | Score 0-9<br>Selection (Max 4*)<br>Comparability (Max 2*)<br>Outcome (Max 3*) |
| *Qualitative Study* | National CASP Appraisal Tool | Score 1-10<br>1-3 (High risk)<br>4-7 (Moderate risk)<br>8-10 (Low risk) |
| *RCT* | National CASP Appraisal Tool | Score 1-11<br>1-3 (High risk)<br>4-7 (Moderate risk)<br>8-11 (Low risk) |
| *Mixed Methods* | MMAT Checklist | Score 0-13<br>Scores varying from 25% (*) - one criterion met to 100% (****) - all criteria met |

<u>Data synthesis:</u>

An integrated synthesis approach (see Figure 14 below, adapted from Person et al., 2015) was used to perform a mixed-method systematic review on the factors related to MWB. Both quantitative and qualitative data were included in descriptive figures, while quantitative data have also been summarised separately in forest plots. A narrative quantitative analysis was used in the second systematic review on the consequences of MWB.

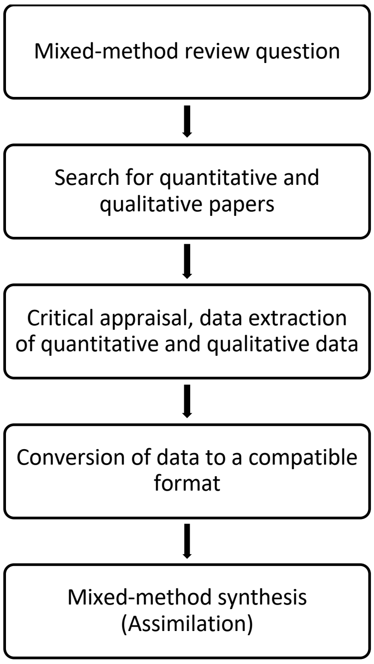



*Figure 14.Integrated Synthesis Approach (Person et al., 2015)*

### 3.4.4 PHASE 2. IDENTIFY AND QUANTIFY THE MODEL OF MWB – QUANTITATIVE ANALYSIS USING HSE AND UKHLS

The primary quantitative analyses were separated into two chapters using two different datasets. Chapter 6 on the distribution of MWB in old age used HSE 2010-2016 7-year datasets since HSE is a cross-sectional survey that includes a large sample size that could catch the trajectory of MWB in old age. Chapter 7 on the determinants and consequences of MWB in old age used UKHLS 2009-2017 9-year datasets. UKHLS is a longitudinal survey and therefore suitable to use in detecting the determinants and consequences. Quantitative analysis was used initially to determine the extent to which the list of potential determinants could explain the observed variations in MWB. Potential determinants were later-life risk factors derived from the phase 1 systematic review in Chapter 4. Quantitative analysis was also used to determine the predictive ability of MWB for ageing well. Moreover, it was used to determine whether MWB could mediate and/or moderate the association between later-life risk factors and ageing well. The analytic methods and statistical models developed and used in each step are listed below.

### *Step 1. Chapter 6 Distribution of MWB in old age*

Analyses of the MWB distribution in old age using 5-year, 3-year and 1-year age bands were performed and compared. A descriptive analysis was undertaken with no control variables. The MWB distribution across life was analysed on 5-year bands using the HSE 2010-2016 7-year combined dataset. A 'drill-down' analysis of the MWB distribution in old age comparing (approximately) 5-year, 3-year and 1-year age bands using the HSE 2010-2014 5-year combined dataset was also undertaken.

### *Step 2. Chapter 7 Determinants of MWB in old age*

Investigation of the determinants of MWB was underpinned by investigation of the association between potential later-life risk factors and older people's MWB using UKHLS 9-year datasets. The primary explanatory variables were derived from the phase 1 systematic review (Chapter 4) and separated into five categories: i) physical health & functioning, ii) social functioning, iii) behavioural & lifestyle, iv) psychological and v) demographic & socio-economic factors. Due to the data available in the UKHLS, only three categories of determinants were included in the analysis (physical health, demographic & socio-economic and psychological factors).

The determinants analysis aimed to specify an MWB function such that the natural logarithm of MWB is a function of individual-level health and social variables. These variables are either more time-variant (including general health, chronic conditions, age, financial situation, marital status, employment status, overall sleeping quality and mental illness) or more time-invariant (including sex, education and religion). Hence a testable function of MWB was designed. Cross-sectional analysis using multiple regression was initially performed. Multiple regression was aimed to include all determinants associated with MWB in the estimated MWB function and identify the dominant determinants of MWB in old age.

In the longitudinal analysis, multilevel modelling using a mixed-effects model was conducted. Multilevel modelling assumes changes over time comprise within-individual components (variation in each individual's characters) and between-individual components (variation across individuals) (Gunasekara et al., 2014, p. 265). Initially, both random-effects and fixed-effects models were conducted. A fixed-effects model assumes individual acts under their own control. It models the within-individual components only and controls for between-individual components, which in other words assumes MWB is associated with time-variant determinants but not time-invariant determinants. A random-effects model, on the other hand, combines variations both from within- and between-individuals. MWB is hence associated with both time-variant and time-invariant determinants. However, in the longitudinal analysis undertaken, the 'between-individual' variation might also include potential confounders – not only observed variables including education, sex and religion but also unobserved variables including general health, chronic conditions, age, financial situation, marital status, employment status, overall sleeping quality and mental illness.

Moreover, the choice between the fixed-effects and the random-effects model is often based upon the Hausman test (Hausman, 1978, pp. 1251-1271). In the analyses presented, although the Hausman test preferred a fixed-effects model, an alternative mixed-effects model was used: the Hausman-Taylor model was used because both time-variant and time-invariant variables were of interest. The Hausman-Taylor model combined the consistency of a fixed-effects model with the efficiency and applicability of a random-effects model (Bandi et al., 2003, p. 362) to meet the analysis needs in this research.

### *Step 3. Chapter 7 Consequences of MWB in old age*

Analyses of the consequences of MWB were conducted by investigating the MWB consequences on ageing well (particularly physically ageing well) using UKHLS 9-year datasets. Random-effects models were used to examine the associations between MWB and its consequences on ageing well. The hypothesis was that higher MWB will enhance physically ageing well in the long term even when controlling for other covariates. In other words, time-lagged MWB (lagged at wave-1) could predict SF-12 PCS – the measure of physically ageing well in this PhD thesis – after controlling for demographic and socio-economic variables, as well as psychological variables. The random-effects model excluded general health to avoid multicollinearity since it is highly correlated to PCS.

### *Step 4. Chapter 7 Mediation and Moderation Effects*

In this chapter, I also underlined the role that MWB might play in ageing well by examining whether MWB mediated and/or moderated the association between later-life risk factors and ageing well using UKHLS 9-year datasets. Baron & Kenny (1986, p. 1173) differentiated the mediator and moderator as follows:

1) the mediator function of a third variable "represents the generative mechanism through which the focal independent variable is able to influence the dependent variable of interest", and
2) the moderator function of a third variable "partitions a focal independent variable into subgroups that establish its domains of maximal effectiveness in regard to a given dependent variable".

*<u>Mediation Effect</u>*

In the mediation model (see Figure 15 below), the following three conditions must be met: a) significant association between the independent variable and the mediator, b) significant association between the mediator and the dependent variable and c) significant association between the independent variable and the dependent variable. The mediation hypothesis is supported if a previously significant association between the independent and dependent variables (c) is significantly decreased or no longer significant after controlling (a) and (b) (Baron & Kenny,1986).

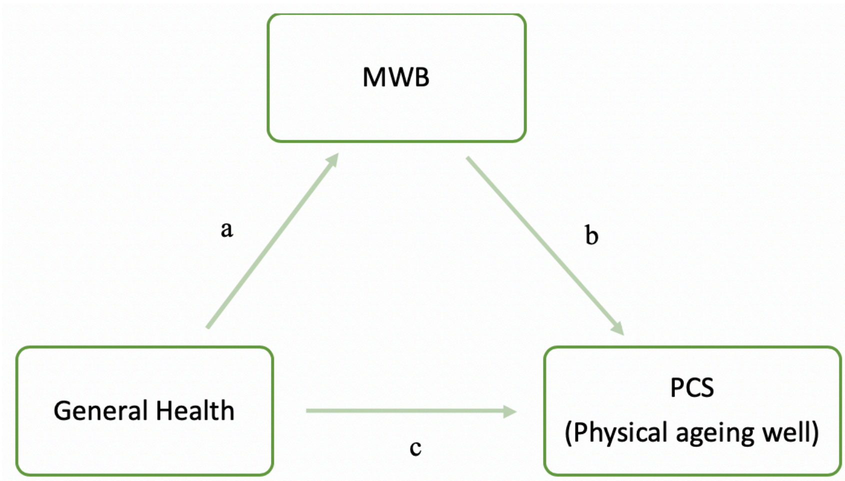



*Figure 15.Hypothetical mediation model (test)*

In order to find out whether MWB mediated the association between later life risk factors and physically ageing well, a structural equation modelling (SEM) was used. Both longitudinal mediation models and path mediation models were designed to investigate the mediation effect. A path diagram presented with β estimates was initially created to explain the longitudinal associations (see Figure 16 below). In the mediation effects analyses, the dependent variable was SF-12 PCS (PCS) while the independent variables were general health (GH) and time-lagged PCS. The mediating variables were MWB and time-lagged MWB. In the path mediation model, each path was presented with the estimated direct effect, total effect and the indirect effect (see Figure 17 below: D for direct effect, I for indirect effect and T for total effect). The indirect effect indicated the mediation effect that MWB and time-lagged MWB have on the association between the dependent variable and the independent variables.

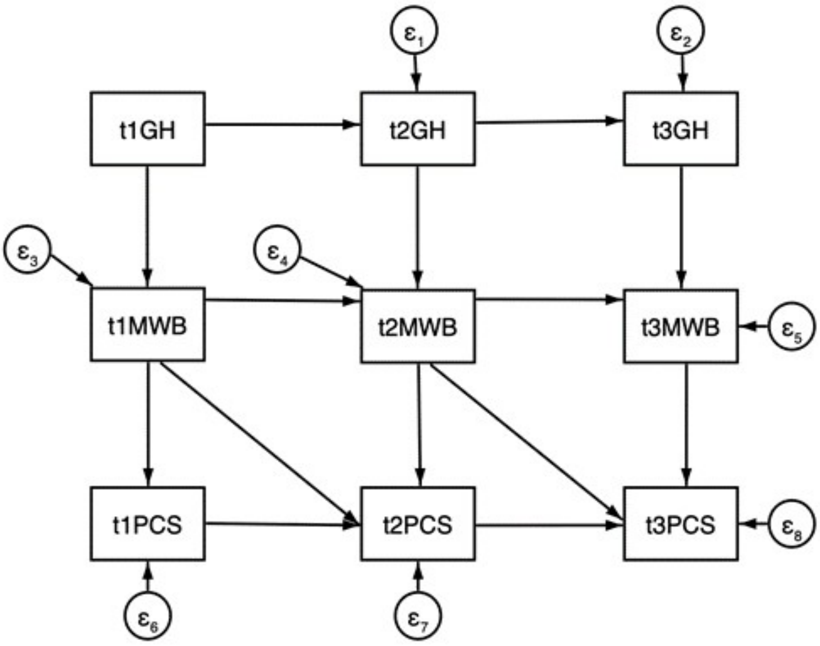



*Figure 16.Path diagram – β estimates (design)*

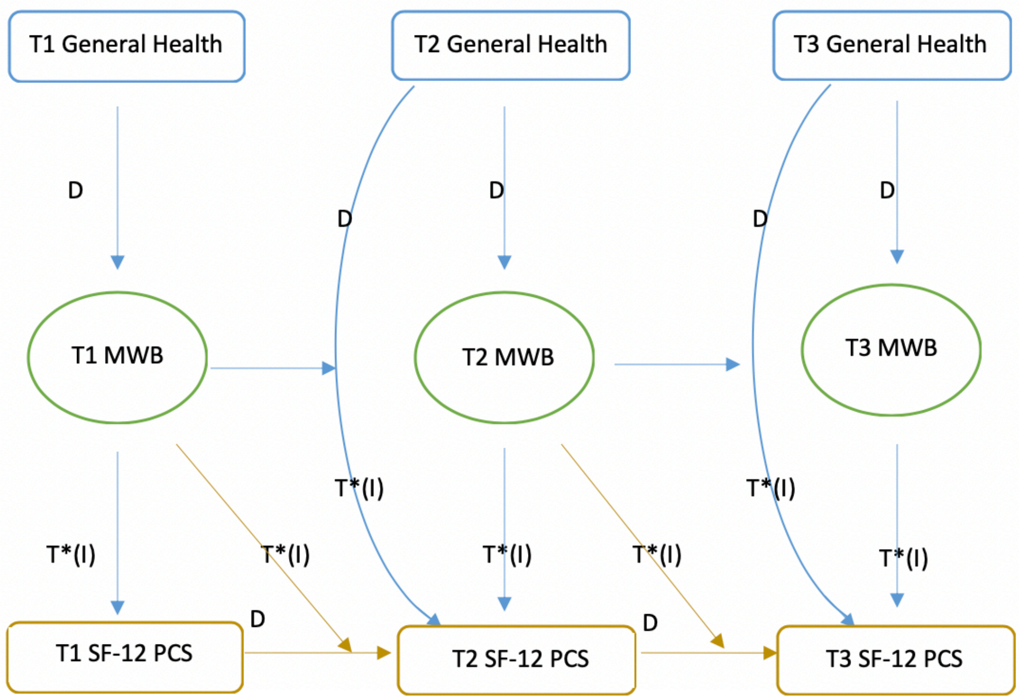



*Figure 17.Mediation effect – path model (design)*

*Moderation Effect*

Moderation occurs when the relationship between the dependent variable and independent variable depends on a third variable. The third variable is referred to the moderator. In the moderation model, there were three associations that need to be addressed (see Figure 18 below): a) association between the independent variable and the dependent variable, b) association between the moderator and the dependent variable, and c) an interaction or product of those two (independent variable and moderator). The moderator hypothesis is supported if the interaction (c) is significant, irrespective of the significance of (a) and (b) (Baron & Kenny,1986).

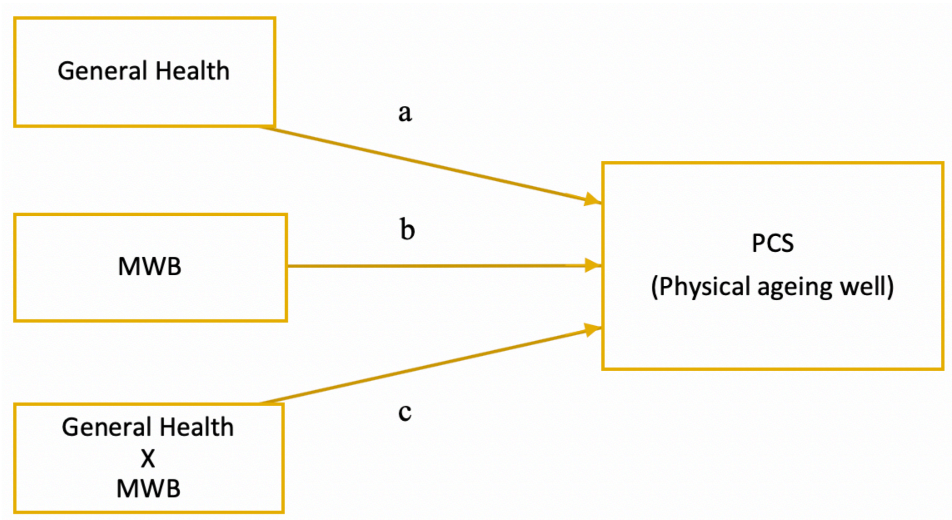



*Figure 18.Hypothetical moderation model (test)*

In the moderation effects analyses, a dichotomous moderator variable (lower or upper quartile of MWB) modifies the association between a continuous dependent variable (current PCS) and continuous independent variable (previous GH or previous PCS). In order to find out whether previous MWB level could moderate this association, a pooled time-lagged multiple regression analysis and robust logistic regression were used. In addition, the moderation effects were presented in graphs.

### 3.4.5 PHASE 3. DISCUSSION AND INTEGRATION

Finally, I discuss and integrate the findings with policy implementation ideas. The role of MWB in older people's ageing well process was underlined. The study findings were firstly integrated, summarised and discussed in terms of study aims and objectives at each phase and compared with existing literature of MWB in old age. Secondly, the methodological issues of the study, its strengths and limitations were discussed. Because lost to follow-up commonly appears for older people in survey datasets, especially secondary datasets with minimal information about the reason for missing data, in this section, the lost to follow-up issue in the primary analysis using UKHLS (Chapter 7) was also discussed. Finally, the contribution of this PhD in terms of policy implications was discussed. The possibilities for future work were also outlined.

## 3.5 SOFTWARE

All statistical analysis was carried out using Stata 15. v2.

## 3.6 ETHICAL APPROVAL

The University of Warwick BSREC were approached for ethical approval on the quantitative phase of the study (see Appendix D for E-mail reference). Since the study engaged publicly available secondary datasets only, it did not require research ethical review.

## 3.7. FEASIBILITY STUDY

This PhD research provides quantitative evidence by drawing on two large, UK national representative survey samples. The datasets this study used are the HSE 2010-2016 and UKHLS (3 waves: 2009-2017). The datasets used are secondary questionnaire data. The main strengths and limitations of using secondary datasets in this PhD are listed in Table 6 below. To address the limitation that missing variables commonly appear for older people in survey data, additional analysis is performed in Chapter 7 to assess the effect of bias on the results.

*Table 6. Strength and limitation*

| STRENGTH | LIMITATIONS |
|---|---|
| Large sample size | Limited information |
| National representative sample | Response rate uncontrolled |
| Easy to get (publicly available) | Missing data and potential bias |
| Cleaned dataset | Possibility of important third variables that are not available for the analysis |
| **Free to cost** | |

## 3.8. CONCLUSION

This chapter has described how the research is designed to fill the gaps in current knowledge of MWB in old age.

This PhD thesis will firstly identify potential determinants (later-life risk factors) and consequences of MWB through two parallel systematic reviews (Chapter 4 and Chapter 5). The two reviews will include a large body of the most recent studies on MWB. Narrative quantitative analysis will be undertaken to synthesise results from reviewed studies. The results from the two systematic reviews will inform the quantitative analysis in Chapter 7.

A descriptive analysis will be undertaken in Chapter 6 to investigate the distribution of MWB in old age. The descriptive analysis will add to current knowledge on variations in MWB distributions in old age by comparing different age bands (5-year, 3-year and 1-year).

Finally, quantitative analyses of the determinants and consequences of MWB in old age will be undertaken in Chapter 7. The quantitative analysis will add to the current knowledge of MWB by 1) investigating the multifactorial associations between MWB and its determinants and those that underpin the dominant determinants of MWB; 2) exploring the consequences of MWB on ageing well; 3) discovering the invisible pillars of MWB on mediating and/or moderating the association between physical health and physically ageing well.

This chapter has described the methodology undertaken in this thesis, including justifications for the measures and models. The following two chapters (Chapter 4 and Chapter 5) present the first phase of this PhD research – the two parallel systematic reviews.

# CHAPTER 4 FACTORS RELATED TO MENTAL WELL-BEING IN COMMUNITY DWELLING OLDER PEOPLE: A SYSTEMATIC REVIEW

## 4.1 INTRODUCTION

There is an international interest in policy that promotes strategies that encourage individuals in 'ageing well'. 'Ageing well' is often used interchangeably or alongside 'healthy ageing', 'flourishing', and 'successful ageing' in public policy and focuses on an individual's experience of their health and overall well-being. In this PhD, ageing well is defined as a state of doing, living and functioning well physically, psychologically and socially.

Maintaining a sense of mental well-being (MWB) and engagement in old age might represent a sign of ageing well psychologically (Baltes & Baltes, 1990; Gale et al., 2013). MWB which refers interchangeably to 'positive mental health', 'positive well-being' and 'well-being', describes both positive functioning (eudaimonic well-being) and positive feelings (hedonic well-being) (Stewart-Brown, 2015, 2018).

Numerous factors may influence the MWB of adults in either a positive or negative way. Research tends to cover single or multiple facets which are: 1) physical factors including physical health and functioning (George, 2010; Sabatini, 2011; Hellström & Hallberg, 2001); 2) demographic and socio-economic factors such as age, gender, education, deprivation, housing and household size, employment and wealth (Blanchflower & Oswald, 2008; Steptoe et.al, 2012; Bellis et al., 2012; Howden-Chapman et al., 2011; Grundy & Read, 2012); 3) behavioural and lifestyle factors, e.g., exercising, eating, drinking and smoking (Cooper et al., 2014; Fox et al., 2007; Tampubolon, 2014); 4) psychological factors, encompassing cognitive function, sense of coherence, mental illness, loneliness and unmet expectations (Allerhand et al., 2014; Van Lente et al., 2012; Schwandt, 2015); and 5) social factors including social relationship and functioning, e.g., marriage status, social capital, providing support to others, receiving social support (Nyqvist et al., 2013; Brown et al., 2003).

Many factors that may be associated with poorer MWB are more common in older people including being widowed, having health-related complaints (including dementia), needing more help with activities of daily living (Hellström et al., 2004), feeling lonely (Ni Mhaolain et al., 2012), and experiencing cognitive impairment (Allerhand et al., 2014). By contrast, participating in social activities (Ormsby et al., 2010; Greaves & Farbus, 2006) and physical activities (Dionigi, 2007; Fox, 2007) support an increase in MWB in old age. As older people from different contextual backgrounds have different life experiences that might affect how they cope with ageing (Schaie, 2008), investigation of the determinants of older people's MWB should incorporate cumulative effects.

Previous reviews examined some of the factors associated with older people's MWB. von Bonsdorff & Rantanen (2011) conducted a systematic narrative review comparing older people (aged 60 above) engaging in voluntary work with non-volunteers. Formal volunteering predicted better life satisfaction. However, the review cannot tell us much about the effect of volunteering on MWB since there was no baseline data available, and the outcome measures were not completely MWB focused. In a meta-analysis, Pinquart & Sörensen (2000) reported that socio-economic status (SES), social network, competence and activity are significantly and positively related to subjective well-being measures (SWB) (life satisfaction, happiness and self-esteem) in old age. However, although they reviewed studies with a mean age of 55, there were several studies focused on the general adult population from age 18 up. Nyqvist et al. (2013) conducted a systematic review of 11 cross-sectional studies and summarised positive associations between parts of social capital and aspects of MWB for older people aged 50 and above. However, the primary explanatory variables (social capital aspects defined as structural, cognitive, bonding, bridging, linking, individual and collective) or outcome measures, aspects of MWB, were different across all studies which make conclusions difficult to draw. In two meta-analyses, Windle et al. (2010) and Net & Wu (2005) both focused on the association between physical activity (PA) and MWB and reported similar results. Windle et al. (2010) reported an overall positive effect of exercise on MWB (standardised effect size 0.27; 0.14–0.40) while Net & Wu (2005) reported a significant positive effect of physical activities on overall well-being, self-efficacy, view of self, and improvement on anxiety. However, the consistency of the association varied across all studies as the types of intervention and the instruments used to measure PA were different. Kojima et al. (2016) conducted a systematic review and meta-analysis on the association between frailty and older people's QoL. Four studies that using SF-36 to measure QoL and Fried criteria (Fried et al., 2001) (focuses on physical components associated with frailty: unintentional weight loss, self-reported exhaustion, weakness, slow walking speed and low physical activity) to define 'frail' were included in their meta-analysis. Their finding demonstrated that frail and prefrail older people had significantly lower mental (SF-36 MCS) as well as physical (SF-36 PCS) quality-of-life scores than those classified as non-frail. Reviews of MWB in old age are challenging due to the multifactorial influences on MWB, and the diversity in MWB measures used. Although there is evidence for cumulative effects, as previous reviews demonstrated links between MWB and voluntary work, SES, social capital and physical activity, no review considered a broad range of factors together. Therefore, an extensive overview of the factors associated with MWB in old age is needed.

The main purpose of the current review is to identify the potential determinants to be tested in the model of MWB in old age. This study will add to the existing literature by 1) including a large body of the most recent studies covering aspects of MWB; 2) investigating five categories of factors related to MWB: i) physical health and functioning, ii) social functioning, iii) behavioural and lifestyle, iv) psychological and v) demographic and socio-economic; 3) including different types of study design (e.g., reviews, cohort studies, cross-sectional studies, longitudinal studies, RCT studies, qualitative studies and mixed methods studies); and 4) subdividing categories of factors associated with MWB by their positive or negative influence. Moreover, this review also intends to shed light on future research on the age cohort difference (e.g. younger old vs older old) in factors associated with MWB. The research questions this review intends to address are:

1) What are the factors that influence older people's MWB in a positive or negative way?
2) Are there any differences across studies on the factors associated with MWB?
3) Will the result indicate a cumulative impact of the factors associated with MWB?
4) Will the associations between the factors and MWB vary with age?

## 4.2 METHODS

PRISMA (Moher et al. 2015) guidelines were used as a framework. Prior to formulating the review, I conducted a scoping review to ensure that a systematic review or meta-analysis pertaining to the research questions had not been previously published or registered. The review protocol was registered on PROSPERO (Registration number: CRD42016048146).

### 4.2.1 SEARCH STRATEGY

I searched: PubMed, Ovid MEDLINE, PsycINFO, Scopus, and Cochrane Library. The search terms were {("Well Being" OR wellbeing OR "well-being" OR "positive mental health" OR "life satisfaction" OR "quality of life" OR happiness) AND (mental OR positive) AND (aging* OR ageing* OR "older people" OR "older adult*" OR pensioner* OR elderly OR geriatric* OR retired)} in Title/Abstract. The reference lists of the retrieved articles and review papers were searched and appraised to identify potentially relevant articles. I (JW) screened 100% of abstracts and full-text articles, and a second reviewer (MD) screened 50% of abstracts and full-text articles as a reliability check.

*Inclusion criteria*

1) Published articles in peer-reviewed journals;
2) Be published in English;
3) Published from January 1990 to the current day of searching (15 June 2017);
4) Populations aged 60 or above (or have a separate analysis on 60 or above) according to the UN's use of old age (UN, 2001);
5) Include a validated measure of MWB (studies using MWB measures considered by most experts such as mental well-being, positive mental health, psychological well-being, life satisfaction, quality of life and happiness). Measurement is not necessary for qualitative research;
6) Include a community-based population;
7) Focus on the determinants of mental well-being in later life;

8) Focus on mental well-being rather than mental illness.

*Exclusion criteria*

1) Books and reviews of books;
2) Well-being or quality of life measures that only measured/related to physical well-being or social well-being;
3) Institutionalised population only, or studies that focus on relocation;
4) Determinants that are concepts of MWB (i.e. coping, resilience, self-esteem, flourishing, integrity, sense of coherence and optimism)
5) Patients/older people with a specific disease;
6) Very specific population (i.e. pre/post-menopausal, sponsor/partner/caregivers of older people with a specified disease, older people specified as from an LGBT group or veterans) (N.B. exceptions in studies focus on widowed older people);
7) Interventions on treatments, drugs, or very specific therapy (i.e. music, Tai Chi and dancing);
8) Protocols, or study design and methodology.

### 4.2.2 DATA EXTRACTION AND QUALITY ASSESSMENT

I developed a data extraction table including the authors, type of study, methods undertaken, sample size and age range, outcome variables, primary explanatory variables, covariates, comparison groups (if applicable) and results. Primary explanatory variables were categorised into five sections: i) physical health and functioning, ii) social functioning, iii) behavioural and lifestyle, iv) psychological and v) demographic and socio-economic (see Table 7). Since social functioning is defined differently in each study, I used an amended version of the social functioning domains (Levin, 2000) with factors indicated a relationship – marital status, living arrangements (live alone or with someone) and neighbourhood also included.

*Table 7. Primary Explanatory Variables (include but not limited to) Categories*

| **Physical health and functioning** | **Social functioning** | **Behavioural** | **Psychological** | **Demographic & socio-economics status** |
|---|---|---|---|---|
| General health<br>Health problems<br>Chronic diseases<br>Functional health<br>ADLs/IADLs difficulties<br>ADLs/IADLs independency<br>Disability<br>Physical capability | Social network<br>Social capital<br>Social support<br>Social relationship<br>Social activity<br>Voluntary<br>Care-giving work<br>Marital status<br>Living arrangement<br>Neighbourhood | Health behaviour-physical activities, exercise, physical check-ups<br>Health behaviour-eating, drinking and smoking | Mental illness<br>Mental health<br>Loneliness<br>Social isolation<br>Losses (job, partner, power)<br>Cognitive function | Age<br>Sex<br>Education<br>Ethnicity<br>Religion<br>Culture<br>Urban<br>Deprivation<br>Household size<br>Economic activities<br>Employment /retirement |

Note:

- Activities of daily living (ADLs) are routine activities people do every day without assistance. Examples of basic ADLs: getting up and down stairs, having a bath or a shower, dressing or undressing, getting around indoors, getting in and out of bed, taking medicine, eating including cutting up food, using the toilet, washing face and hands.
- Instrumental Activities of Daily Living (IADLs) are activities related to independent living and examples of basic IADLs are shopping for food, doing routine housework or laundry, getting out of the house, doing paperwork or paying bills.

(All examples are from Health Survey England measures of ADLs and IADLs)

Articles adhering to the inclusion criteria were quality assessed (QA) for final inclusion in the review. Due to the variety of study designs, the quality assessment was undertaken separately using the Newcastle Ottawa Scale (NOS) (Well et al., 2012) for cross-sectional, longitudinal and cohort studies; using the National CASP Appraisal Tool (CASP, 2017) for qualitative studies and RCTs and the Mixed Methods Appraisal Tool (MMAT) (Pluye et al., 2011) for mixed methods studies (for QA scoring methods see Appendix B: Review – 1. Factors related to MWB – 1.2 Quality Assessment Methods). A summarised table with QA scores on all included studies was presented. As the main purpose of this review was to find out the potential determinants of MWB in old age, quality assessment was taken for all included studies. Poor quality studies were excluded for data extraction.

### 4.2.3 DATA SYNTHESIS

I performed a mixed-method systematic review using an integrated synthesis approach (see Figure 19 below, Person et al., 2015). Both quantitative and qualitative data were included in descriptive figures, while quantitative data also separately summarised in forest plots.

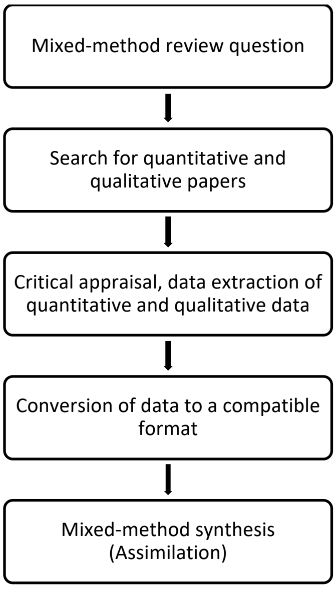



*Figure 19.Integrated Synthesis Approach (adapted from Person et al., 2015)*

## 4.3 RESULTS

Figure 20 (see below) presents the results of the search. A total of 18,078 studies were identified by the search terms. After removing duplicates, 14,202 citation titles and abstracts were screened for inclusion by JW (100%) and MD (50%). A disagreement between reviewers (per cent agreement=81) was discussed until a final consensus was reached. 13,987 studies were excluded at the abstract stage. Six further studies were identified by hand search, giving a total of 219 full-text articles. One hundred and fiftytwo studies were excluded, leaving 67 papers eligible for quality review (details see Appendix B: Review – 1. Determinants of MWB – 1.1 The summarised findings from reviewed papers).

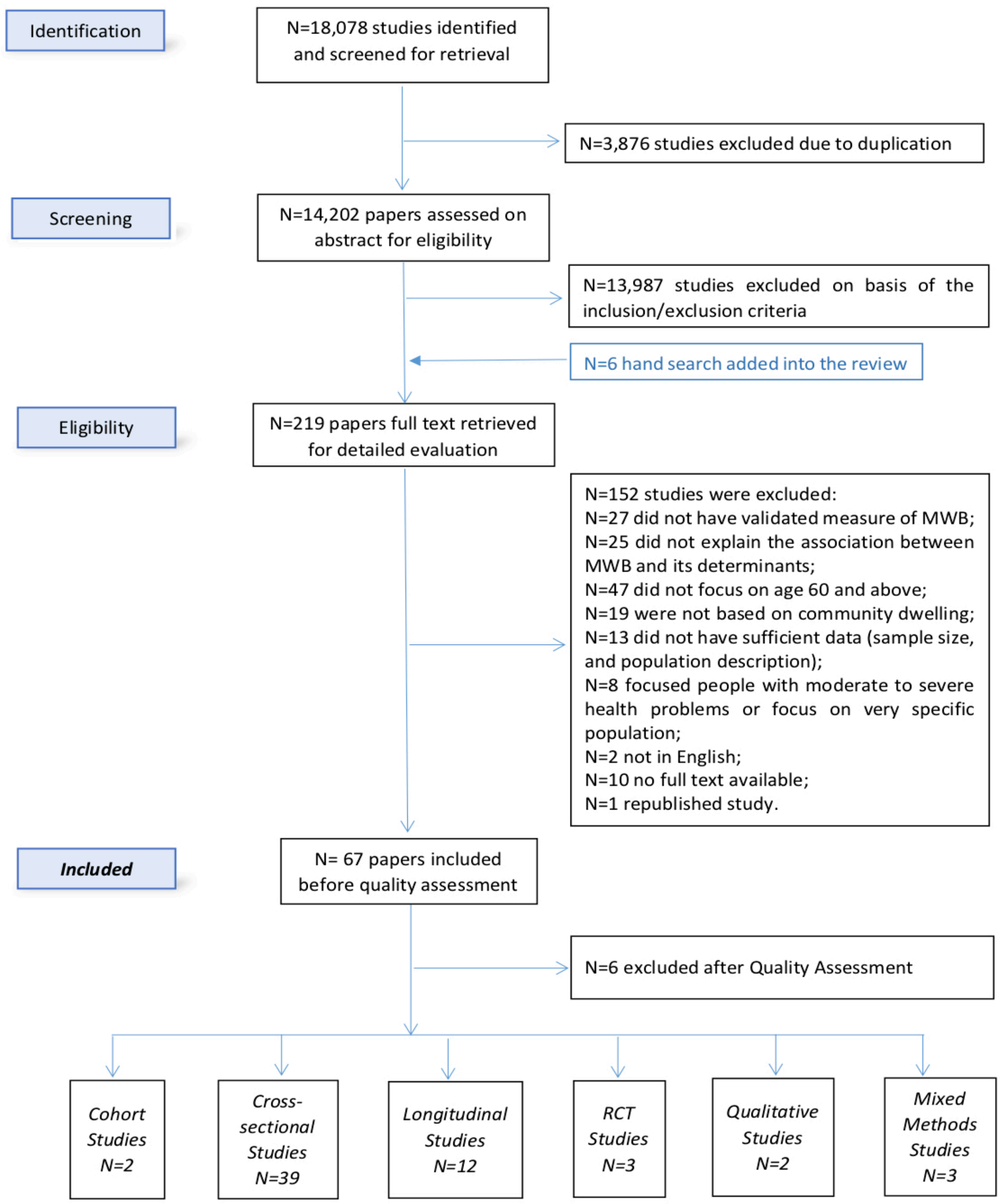



*Figure 20.Flow diagram of the review*

After quality appraisal (details see Appendix B: Review – 1. Determinants of MWB – 1.3 Quality Assessment Results), six papers were removed due to poor quality. Sixty-one papers were included in the final synthesis, including two cohort studies, thirty-nine cross-sectional studies, twelve longitudinal studies, three RCT studies, two qualitative studies and three mixed methods studies (see Figure 20). The results of quality appraisal demonstrated that 70% (43 papers) of the reviewed studies suffered from a moderate risk of bias, while only 7% (4 papers) had a low risk of bias. 23% (14 papers) of the reviewed studies were identified as low-quality studies. 66% (40 papers) and 11% (7 papers) were identified as moderate-quality and high-quality, respectively.

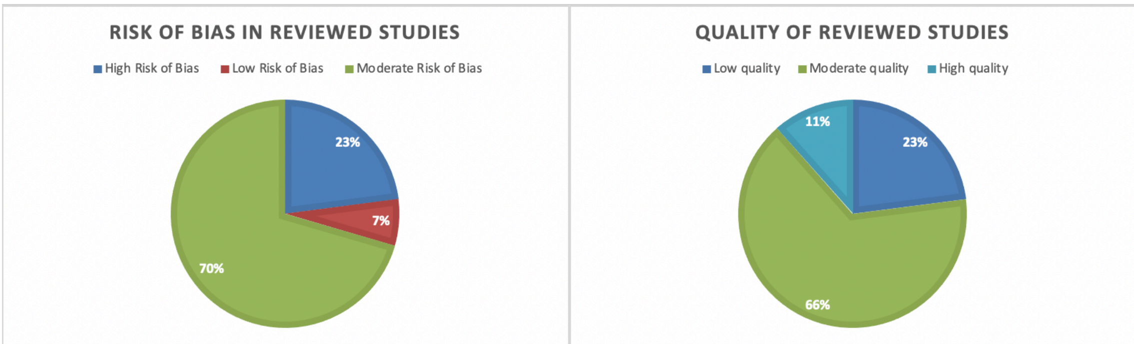



*Figure 21. Results of quality appraisal*

### 4.3.1 MEASURES

*Mental Well-being*

In our review, MWB was defined as the combination of hedonic well-being (Mroczek & Kolarz, 1998) and the psychological (Ryff, 1989; Ryff & Keyes, 1995) and social aspects of eudaimonic well-being (Keyes, 1998, 2013). The constructs of the most commonly used measures in the reviewed studies were summarised as seen in Table 8. These measures covered seven constructs of MWB: positive affect, subjective accounts of individuals' happiness, satisfaction of life, psychological functioning (autonomy, competence, self-acceptance and personal growth), interpersonal relationships, purpose in life and vitality.

*Table 8. Constructs of MWB Measures from the Review*

**Constructs of Mental Well-being (most commonly used measures in reviewed studies)**

| Measures | Number of studies | Positive affect | Happiness | Satisfaction of life | Psychological functioning | Interpersonal relationships | Purpose in life | Vitality |
|---|---|---|---|---|---|---|---|---|
| Satisfaction with Life Scale (SWLS) | 13 | | | √ | | | | |
| Short Form 36 Scale (SF-36)/Short Form 12 Scale (SF-12) | 11 | √ | | | √ | √ | | √ |
| Life Satisfaction Scale/Index | 10 | √ | √ | √ | | | √ | |
| Ryff PWB scale | 4 | | | | √ | √ | √ | |
| Warwick-Edinburgh Mental Well-being Scale (WEMWBS) | 3 | √ | √ | | √ | √ | | √ |
| The Memorial University of Newfoundland Scale of Happiness | 3 | √ | √ | | | | | |
| CASP-19 | 2 | √ | √ | √ | √ | √ | √ | √ |
| General Well-being Scale (GWB) | 2 | √ | √ | √ | √ | | | √ |

## 4.3.2 FACTORS RELATED TO OLDER PEOPLE'S MWB

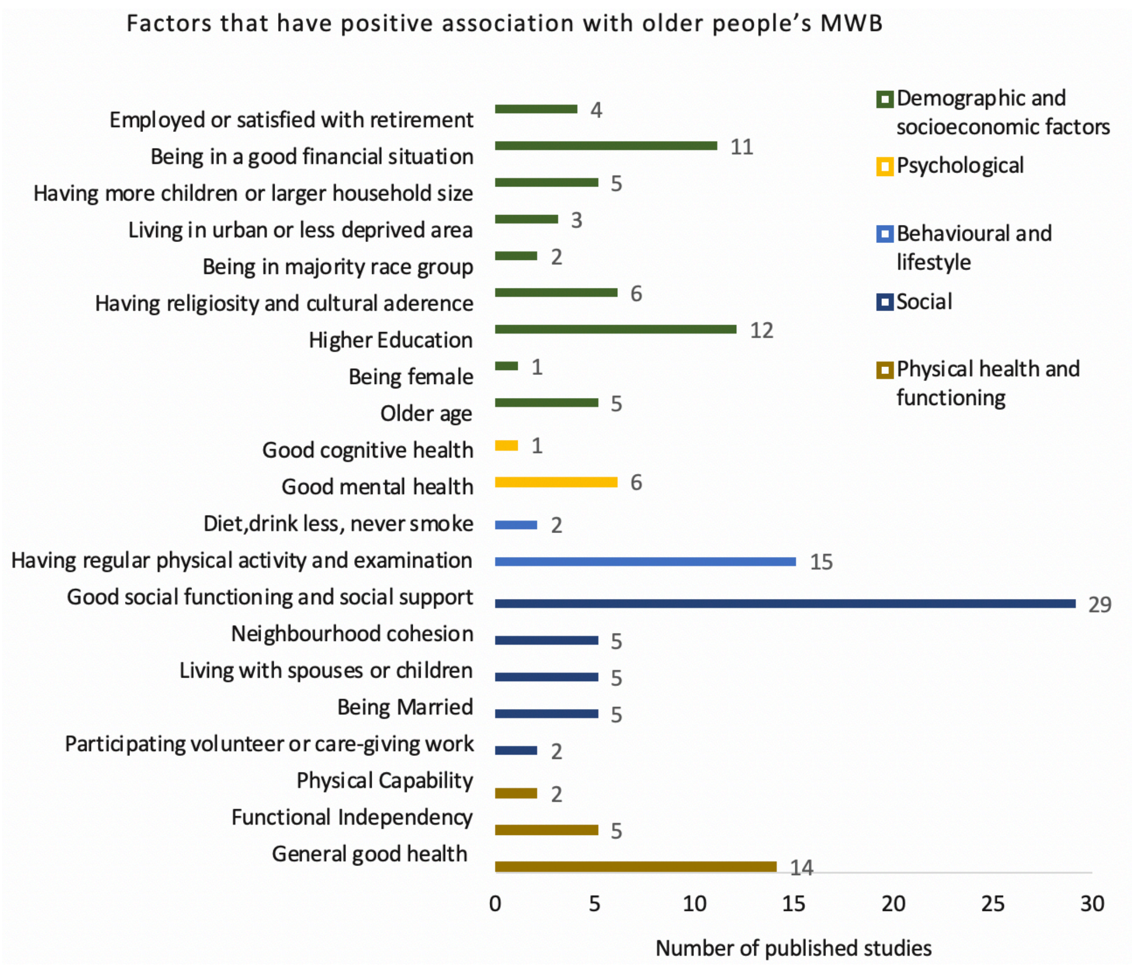
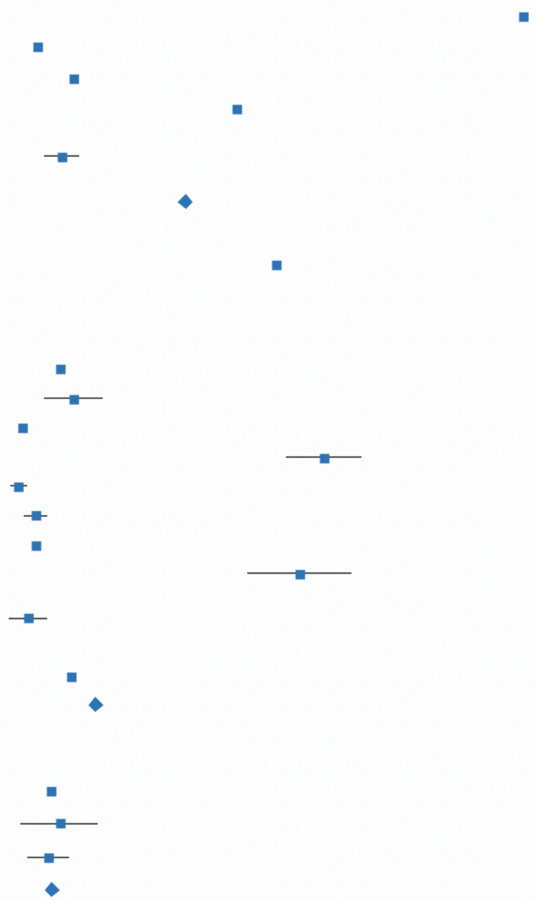


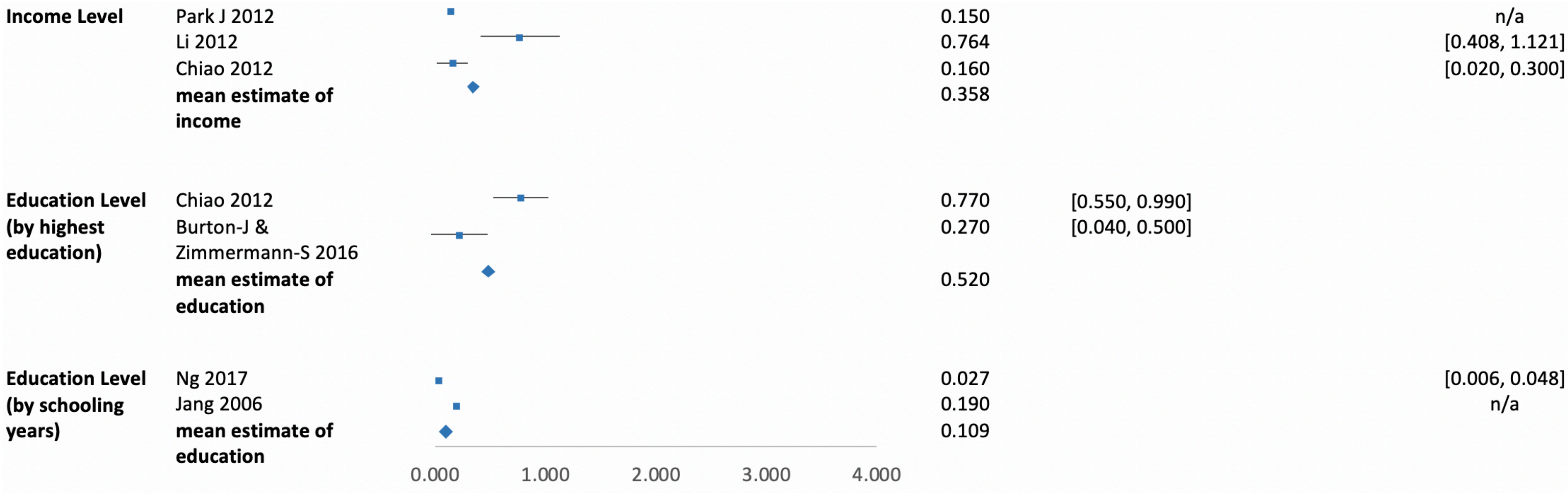

*Figure 22.Factors that have positive association with older people's MWB (Frequency)*

Twenty-nine studies demonstrated a positive association between good social functioning or social support and MWB in old age including having social support, having or engaging in a social network and having a good relationship with social contacts (see Figure 22 above). Other factors that positively associated with MWB were regular physical activities and check-ups, general good health, higher education level and being in a good financial situation. It was also recognised that being in an older-old age cohort and majority race group, being female and married, having functional independence and physical capability, having good mental health and cognitive health, participating in volunteer or care-giving work, living with spouses or children, having neighbourhood cohesion and a larger household size, living in an urban or less deprived area, having good health behaviour including a good diet, less alcohol consumption and never smoking, having religiosity and cultural adherence and being employed or satisfied with their retirement were all positively associated with older people's MWB.

Narrative quantitative analysis of the factors that have a positive association with older people's MWB from the univariate studies was summarised in the forest plots in Figure 23. Due to methodological heterogeneity, including different measures of MWB and different adjustments for confounding between studies, meta-analysis could not be conducted. Figure 23 summarised the results from the quantitative studies reviewed (presented as squares) and presented the unweighted estimated mean (presented as diamonds) of the results in the forest plots to demonstrate the positive association between a related factor and older people's MWB. In summary, more frequently reported significant associations with better MWB were good health, functioning independence, social support and functioning, income and education level. General good health associated with better MWB with an unweighted estimated mean of 1.389 (range: 0.290~3.876; 99.9%CI; SE=0.674). Functional independence (and ADL/IADL independence) also associated with better MWB with an unweighted estimated mean of 1.88 (95%CI). Older people who have a higher level of satisfaction with social support, have or engage in their social network and have a good relationship with their social contacts also reported greater MWB. This positive association varied between 0.082~2.155 with an unweighted estimated mean of 0.611 (SE=0.247) at 99.9%CI, and an unweighted estimated mean of 0.234 (SE=0.025) at 99%CI. In this review, income levels slightly associated with better MWB with an unweighted estimated mean of 0.358 (range: 0.150~0.764; 95%CI; SE=0.203) while higher education level by highest certification (mean estimate: 0.520; range: 0.270~0.770; 99.9%CI; SE=0.250) or by more schooling years (mean estimate: 0.109; range: 0.027~0.190; 95%CI; SE=0.082) also slightly associated with better MWB.

| Determinants | Author | Estimate | Confidence Intervals [99.9%] | Confidence Intervals [99%] | Confidence Intervals [95%] |
|---|---|---|---|---|---|
| **General Health (GH) /Good Health** | Park M 2014 | 3.876 | n/a | | |
| | Park J 2012 | 0.290 | n/a | | |
| | Okabayashi 2004 | 0.550 | n/a | | |
| | Jang 2006 | 1.760 | n/a | | |
| | Burton-J & Zimmermann-S 2016 | 0.470 | [0.338, 0.602] | | |
| | **mean estimate of GH** | 1.389 | | | |
| **Functional Independence** | Windle & Woods 2004 | 1.880 | | | [1.854, 1.906] |
| **Social Functioning & Support** | Yoon & Lee 2007 | 0.360 | n/a | | |
| | Thanakwang 2012 | 0.450 | [0.253, 0.647] | | |
| | Sun 2015 | 0.105 | n/a | | |
| | Park M 2014 | 2.155 | [1.902, 2.408] | | |
| | Ng 2017 | 0.082 | [0.024, 0.140] | | |
| | Li 2012 | 0.194 | [0.112, 0.276] | | |
| | Huxhold 2013 | 0.190 | n/a | | |
| | Gale 2011 | 1.990 | [1.630, 2.340] | | |
| | Burton-J & Zimmermann-S 2016 | 0.140 | [0.008, 0.272] | | |
| | Alpass 2000 | 0.440 | n/a | | |
| | **mean estimate of SF& support** | 0.611 | | | |
| | Park J 2012 | 0.220 | | n/a | |
| | Kirchmann 2013 | 0.283 | | [0.004, 0.562] | |
| | Gow 2007 | 0.200 | | [0.045, 0.355] | |
| | **mean estimate of SF& support** | 0.234 | | | |






Note: The figures on MWB vs its determinants drew on the original results from the reviewed quantitative studies. The reported estimate from each study was represented by square. Each horizontal line represented the confidence interval of the reported estimate. For studies that didn't report their confidence intervals or standard errors, only reported estimate were presented. The diamond represented the mean estimate of grouped studies.

*Figure 23. Correlations between positive related factors and older people's MWB*

.

The most common reviewed factors that negatively associated with older people's MWB were having health problems or chronic diseases, reported in 11 of the 61 studies, having difficulties with ADLs (IADLs) or functional limitations and having mental illnesses (see Figure 24 below). The other factors that have negative association with older people's MWB were being at an older age and in a minority race group, being female, being unmarried or widowed, having general bad health and being frail or disabled, feeling lonely, not participating in volunteer or care-giving work, living alone, having housing or neighbourhood difficulties and bad relationships or not receiving support, having a low education level, not consuming alcohol, being less religious, and having poor economic status. Nevertheless, in different studies, being in an older age cohort, being female and consuming alcohol were demonstrated to have contradictory associations with older people's MWB.

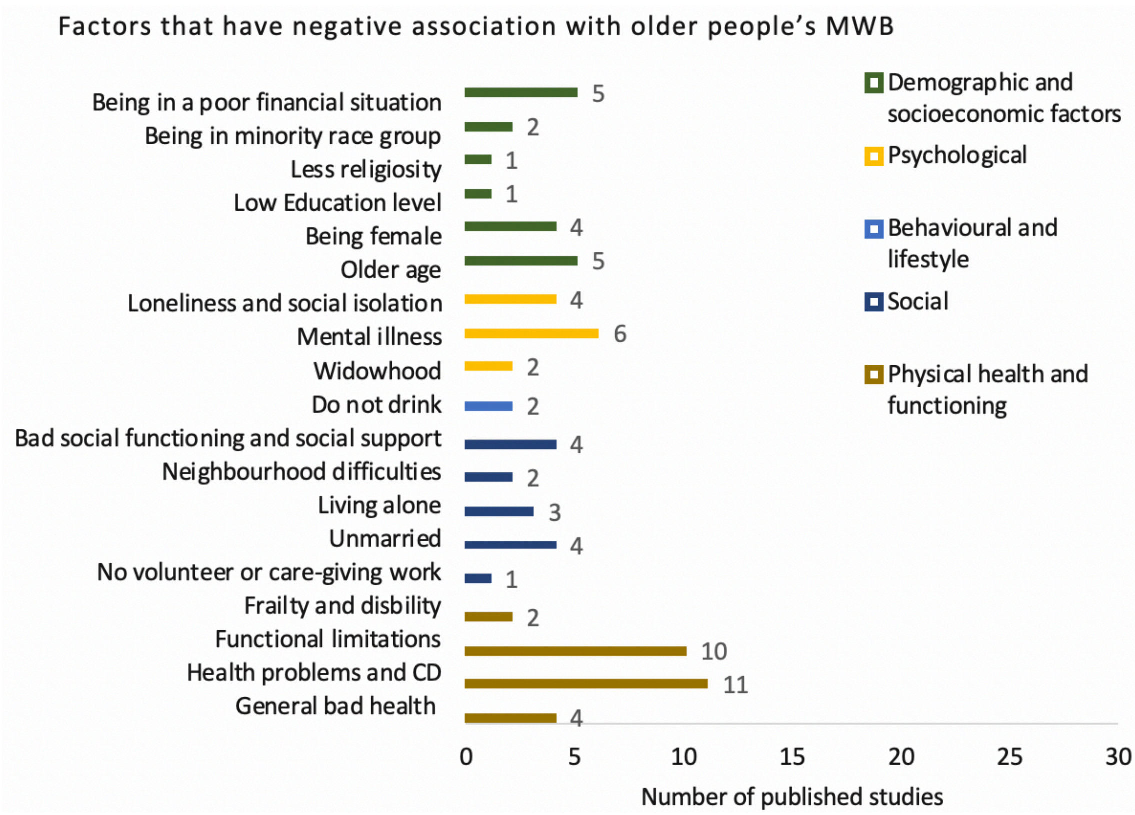
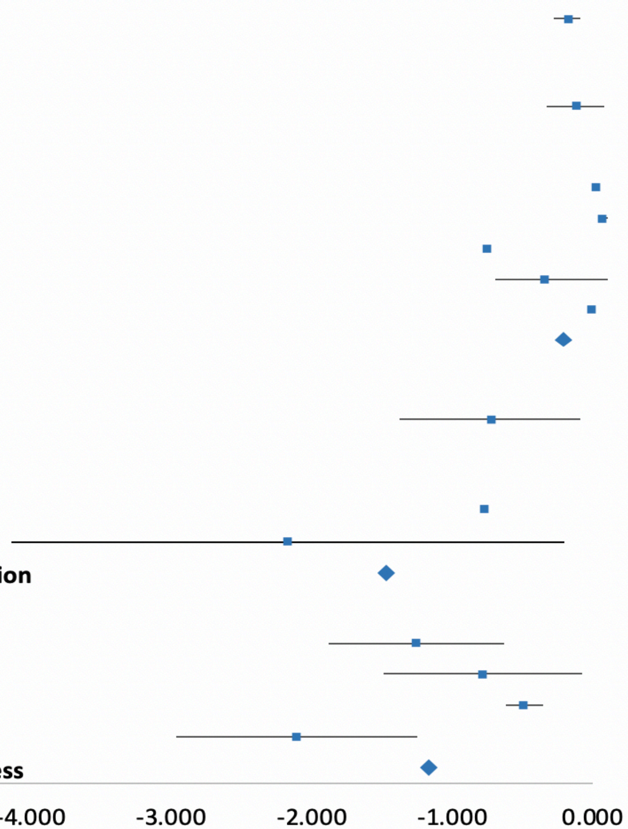



*Figure 24. Factors that have negative association with older people's MWB (frequency)*

The negative association between the reviewed related factors and older people's MWB from univariate studies were summarised in the forest plots in Figure 25 by unweighted estimated mean of the results from reviewed studies. In the reviewed studies, chronic disease (CD), functional limitations (commonly measured by ADL/IADL limitations), depression and loneliness were all recognised to be negatively associated with MWB. In general, having more numbers of CD and functional limitations increased the risk of low MWB. The narrative quantitative analysis demonstrated a negative association between MWB and CD (-0.202, 99%CI; -0.19, 99.9%CI), and between functional limitations and MWB (-0.685, 99%CI; -0.307, range: -0.84~-0.053, 99.9%CI, SE=0.150). Two facets of psychological factors that strongly and consistently associated with lower MWB in old age were depression and loneliness. When summing up the influence of depression and loneliness on MWB in reviewed studies, depression negatively associated with MWB with an unweighted estimated mean of -1.508 (range: -2.230~-0.786; 99.9%CI; SE=0.722) and loneliness negatively associated with MWB with an unweighted estimated mean of -1.160 (range: -2.11~-0.489; 99.9%CI; SE=0.177).

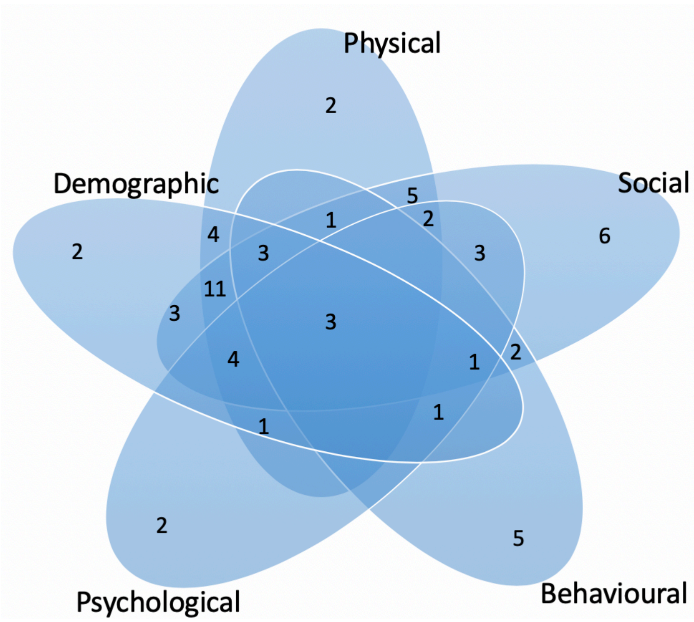
| Determinants | Author | Estimate | Confidence Intervals [99.9%] | Confidence Intervals [99%] |
|---|---|---|---|---|
| Chronic Disease (CD) | Chiao 2012 | -0.190 | [-0.280, -0.090] | |
| | Kahana 2013 | -0.202 | | [-0.401, -0.003] |
| Functional Limitations (FL) | Silverstein 2006 | -0.085 | n/a | |
| | Ng 2017 | -0.053 | [-0.092, -0.014] | |
| | Greenfield & Marks 2004 | -0.840 | n/a | |
| | Chiao 2012 | -0.440 | [-0.550, -0.340] | |
| | Chao 2012 | -0.116 | n/a | |
| | **mean estimate of FL** | -0.307 | | |
| | Kahana 2013 | -0.685 | | [-1.333, -0.037] |
| Depression | Park M 2014 | -0.786 | n/a | |
| | Ní Mhaoláin 2012 | -2.230 | [-4.244, -0.216] | |
| | **mean estimate of depression** | -1.508 | | |
| Loneliness | Windle & Woods 2004 | -1.260 | [-1.885, -0.635] | |
| | Ní Mhaoláin 2012 | -0.782 | [-1.486, -0.078] | |
| | Heo 2015 | -0.489 | [-0.621, -0.357] | |
| | Gow 2007 | -2.110 | [-2.970, -1.250] | |
| | **mean estimate of loneliness** | -1.160 | | |




Note: The figures on MWB vs its determinants drew on the original results from the reviewed quantitative studies. The mean correlation was represented by square. Each horizontal line represented the confidence interval of the mean correlations. For studies that didn't report their confidence intervals or standard errors, only mean correlations were presented. The diamond represented the mean estimate of grouped studies' mean correlation.

*Figure 25. Mean estimates between negative determinants and older people's MWB*

The findings of the review also indicated a cumulative impact of the factors associated with MWB. The number of related factor categories included in each study varies: 17 of the 61 studies focused on a single category, 17 studies consisted of 2 categories, 16 studies consisted of 3 categories, 8 studies consisted of 4 categories and 3 studies consisted of all 5 categories. The most common reported cumulative impact was combined from physical health & functioning, social functioning, and demographic & socio-economic categories, which reported in 11 of the 61 reviewed studies. The other common combinations were physical health & functioning and social functioning (5 studies), physical health & functioning and demographic & socio-economic factors (4 studies), and physical health & functioning, social functioning, psychological, and demographic & socio-economic (4 studies) (see Figure 26 below).




| One | Two | Three | Four | Five | n |
|---|---|---|---|---|---|
| Physical Health and Functioning | | | | | 2 |
| Social | | | | | 6 |
| Behavioural | | | | | 5 |
| Psychological | | | | | 2 |
| Demographic | | | | | 2 |
| Physical Health and Functioning | Social | | | | 5 |

| | | | | | |
|---|---|---|---|---|---|
| Physical Health and Functioning | Behavioural | | | | 0 |
| Physical Health and Functioning | Psychological | | | | 0 |
| Physical Health and Functioning | Demographic | | | | 4 |
| Social | Behavioural | | | | 2 |
| Social | Psychological | | | | 3 |
| Social | Demographic | | | | 3 |
| Behavioural | Psychological | | | | 0 |
| Behavioural | Demographic | | | | 0 |
| Physical Health and Functioning | Social | Behavioural | | | 1 |
| Physical Health and Functioning | Social | Psychological | | | 2 |
| Physical Health and Functioning | Social | Demographic | | | 11 |
| Physical Health and Functioning | Behavioural | Psychological | | | 0 |
| Physical Health and Functioning | Behavioural | Demographic | | | 0 |
| Physical Health and Functioning | Psychological | Demographic | | | 1 |
| Social | Behavioural | Psychological | | | 0 |
| Social | Behavioural | Demographic | | | 0 |
| Social | Psychological | Demographic | | | 0 |
| Behavioural | Psychological | Demographic | | | 1 |
| Physical Health and Functioning | Social | Behavioural | Psychological | | 0 |
| Physical Health and Functioning | Social | Behavioural | Demographic | | 3 |
| Physical Health and Functioning | Social | Psychological | Demographic | | 4 |
| Physical Health and Functioning | Behavioural | Psychological | Demographic | | 0 |
| Social | Behavioural | Psychological | Demographic | | 1 |
| Physical Health and Functioning | Social | Behavioural | Psychological | Demographic | 3 |

*Figure 26. Frequency of Studies Identifying the Determinants of Older People's MWB: a Venn diagram and table of the number of studies containing each of the combinations of the five categories*

Three studies consisted of all five categories. Gabriel & Bowling (2004) completed a qualitative study, and purposively interviewed 40 men and 40 women in the UK. They concluded that from older people's perception of QoL, the good things that gave their life quality were social relationships (96%), social roles and activities (80%), other activities enjoyed alone (93%), having health (85%), psychological well-being (96%), home and neighbourhood (96%), financial circumstances (73%) and independence (69%). Ng (2017) performed a cross-sectional study of 6,530 oldest-old people aged 80 and above in China and used a single subjective measure of life satisfaction – "How satisfied the respondents are with life". Their findings suggested that having good self-rated health, mental health and regular physical check-ups, having better perceived economic status and commercialised insurances, being city resident and living with family, having more schooling years and access to social services were all significantly and positively associated with life satisfaction. On the other hand, being a male and having more IADL difficulties were negatively associated with life satisfaction. Moreover, they reported that having very good self-rated health ($b=3.806$; $SE=0.1379$; $p<0.001$) and better perceived economic status ($b=2.259$; $SE=0.1088$; $p<0.001$) were the most influential factors. Sun (2015) also performed a cross-sectional study of 3,714 older urban Chinese's QoL. They suggested that better SF-36 mental health composite scores (MCS) was significantly associated with having no chronic disease and good visual ability, having good sleeping quality, being married and of the majority ethnicity, experiencing good filial piety, maintaining a regular diet and exercise, consuming alcohol and never smoking. Multiple regression was used in most of the quantitative studies to investigate the complex interrelatedness and the cumulative effect of the factors associated with MWB. There was some evidence of cumulative effects where having good physical health, no disabilities or functional limitations, receiving or having access to social support were found positively associated with older people's MWB (Bowling & Gabriel, 2007; Burton-Jeangros & Zimmermann-Sloutskis, 2016; Chao, 2012; Merz & Huxhold, 2010; Ng et al., 2017; Okabayashi et al., 2004; Park et al., 2012). Cumulative physical health and mental health impact were also commonly found in reviewed studies. Good physical and mental health always associated with high MWB (Bowling & Gabriel, 2004; Lim et al., 2017; Ng et al., 2017; Sun et al., 2015) while poor physical and mental health always associated with low MWB (Ju et al., 2016; Waddell & Jacobs-Lawson, 2010).

The final research question was whether the factors associated with older people's MWB vary among different age cohorts. Cooper (2011) demonstrated that compared with younger people under 60, being married was significantly and positively associated with happiness for older people aged 60-69, while additionally having fewer functional limitations and drinking less alcohol also significantly and positively predicted happiness for older people aged 70-79. However, for older people aged 80+, having fewer functional limitations, having qualifications and religious attendance significantly and positively predicted happiness. Elliott (2014) suggested that age moderated the association between neighbourhood cohesion and well-being, with neighbourhood cohesion more strongly associated with well-being in older age cohorts. Kobayashi (2015) demonstrated that being married had a stronger positive association with life satisfaction among later birth cohorts (born between 1925–1949) than earlier birth cohorts (born between 1901–1924) for men but not for women. Co-residence with a child and life satisfaction had a stronger positive association among earlier birth cohorts than later birth cohorts for women but not for men. The positive association among financial status and life satisfaction and the negative association among functional limitations and life satisfaction were consistent over birth cohorts for both men and women.

## 4.4 DISCUSSION

This review integrated the bulk of studies on the association of MWB with physical health and functioning, social functioning, behavioural and lifestyle, psychological, and demographic and socio-economic factors. The main purpose was to identify the key determinants and their association with MWB in old age.

The findings are summarised as follows:

1. *Association between physical health & functioning and MWB*

Despite increases in life expectancy, declining health functioning and increasing long-term illness and disability are still common among older people. In this review, general bad health, chronic disease, functional limitations, frailty and disabilities were all demonstrated to be negatively associated with older people's MWB. The association between having bad health status, having increased functional limitation and low perceived MWB for older people did not vary among men and women (Waddell & Jacobs-Lawson, 2010; Kobayashi, 2015; Zimmer & Lin, 1996). Meanwhile, the negative association among functional limitations and MWB also increased as the severity of functional impairment increased (Kadowaki, 2015). Moreover, frail older people also had significantly worse MWB compared with robust older people (Andrew, 2012; Bilotta, 2010). However, having a higher number of chronic diseases might affect people differently, as Zimmer & Lin (1996) demonstrated a much stronger correlation between chronic disease and lower MWB for men than for women.

On the other hand, good health, functioning well, and good physical capability were recognised to be associated with better MWB. Older people with better health and more functional independence were more likely to report good quality of life (Bowling & Gabriel, 2007; Gabriel & Bowling, 2004). It has also been noted that physical capability (Cooper, 2014) and body strength (Gouveia, 2017) were also positively associated with older people's MWB. Moreover, for married older people, their partners' good health could also affect their own MWB (Margelisch, 2017).

2. *Association between social functioning and MWB*

As Gabriel & Bowling (2004) and Bowling & Gabriel (2007) summarised from their qualitative studies, good things that also gave older people life quality were social relationships, social roles and activities, and home and neighbourhood. Good social support and functioning was also demonstrated in our review to be the most commonly reported positive determinants of older people's MWB. Older people with more help/support (Bowling & Gabriel, 2007), and those who reported more social engagement (Golden, 2009) were more likely to rate their quality of life as good. However, evidence also suggested that only continuous social support was related to improvements in life satisfaction (McAuley, 2000). Additionally, the source of support also yielded slightly different results. Receiving support from family members rather than from a formal organisation had a significantly stronger association with older people’s MWB (Chao, 2012; Okabayashi, 2004). Besides, engaging in volunteering or care-giving work (Greenfield & Marks, 2004; Kahana, 2013) also predicted higher positive affect, which indicated that not only receiving but also providing support to others was positively associated with older people's MWB. Further analysis of the volume of support provided might also be needed before the conclusion can be drawn.

Neighbourhood cohesion was demonstrated to be positively related to older people's MWB (Gale, 2011; Ye & Chen, 2014; Elliott, 2014), although Elliott (2014) also indicated that age was a moderator, with neighbourhood cohesion more strongly associated with MWB in older cohorts. Also, living with a partner or co-residence with family were also demonstrated to be positively related to older people's MWB (Burton-Jeangros & Zimmermann-Sloutskis, 2016; Chao, 2012; Ng, 2017).

Being married was demonstrated to be significantly and positively related to older people's MWB (Jang, 2006; Sun, 2015). However, different findings and conclusions were also reviewed. Cooper (2011) demonstrated that being married significantly and positively predicted happiness for older people aged 60-69 and older people aged 70-79 compared with younger people under 60, but not significantly for older people aged 80+.

Zimmer & Lin (1996) demonstrated that being married significantly and positively predicted MWB for men but not for women. Kobayashi (2015) cross-compared with age and gender and indicated that being married and life satisfaction had a stronger positive association among later birth cohorts (born between 1925–1949) than earlier birth cohorts (born between 1901–1924) for men but not for women.

On the other hand, those who were unmarried also express lower levels of MWB (Ju, 2016; Kadowaki, 2015; García, 2005). However, Waddell & Jacobs-Lawson (2010) indicated that this association was only significant in men but not in women. Older people's MWB was also negatively associated with living alone (Gouveia, 2017; Ju, 2016), infrequent contact with family or neighbours (García, 2005; Ju, 2016) and being unsatisfied with their relationship with their family and social network.

### 3. *Association between behaviour & lifestyle and MWB*

There is a growing body of interest in the possibility that physical activity (PA) and exercise confer favourable health outcomes, including MWB, across the lifespan. In general, prospective observational studies included in this review showed a positive association between regular PA and MWB in old age. PA contributed to all dimensions of subjective well-being except material well-being (Stathi, 2002). Regular exercise or PA was demonstrated to have a significantly higher association with an increase of MWB (Li, 2012; Ní Mhaoláin, 2012; Vagetti, 2015), while taking a walk had a weaker association (Sun, 2015; Vagetti, 2015). Moreover, results from intervention studies suggested that both volume and frequencies of physical activities might moderate the effect (de Souto Barreto, 2014; Fox, 2007; Vagetti, 2015). Additionally, the effect of earlier PA on later MWB significantly reduced during long-term follow-up (McAuley, 2000; Van Hoecke, 2014).

Previously, little was known about the potential impact of drinking/eating behaviours on MWB in later life. In this review, alcohol consumption presented with a different association on older people's MWB. Cooper (2011) suggested that drinking less alcohol significantly and positively predicted happiness for older people aged 70-79 compared with younger people under 60, but this effect did not hold for older people aged 60-69 and aged 80+. On the other hand, Sun (2015) suggested that mild alcohol consumption was associated with better SF-36 MCS, however, the reason was unknown. The evidence from this review was insufficient to draw a conclusion and further research on the association between drinking/eating behaviours and older people's MWB is needed.

4. *Association between psychological factors and MWB*

Only a few studies in this review had examined positive psychological determinants of older people's MWB. However, the results were hard to conclude since the reviewed studies had concentrated on different mental health indicators. Ng (2017) indicated that higher score from the Mini-Mental State Examination (MMSE) was a significant determinant while Ní Mhaoláin (2012) suggested underlying personality traits of extroversion, Gale (2011) suggested emotional stability and Sun (2015) suggested good sleeping quality were all independent determinants of MWB. Furthermore, Banjare (2015) indicated that better cognitive health was also significantly associated with higher life satisfaction for both men and women. However, Banjare's study lacked a validated measure of cognitive health.

On the other hand, depression and loneliness were relatively consistently associated with lower MWB in old age. Becoming widowed was also mentioned as a negative determinant of older people's MWB. Burns (2015) summarised that for both men and women, becoming widowed was strongly related to a decrease in positive affect after the partner's death. However, this effect was only significant at the time of widowhood. Positive adaption could significantly reduce the negative effect after the partner's loss. Nonetheless, reviewed studies demonstrated that the negative effect of widowhood was reduced when other factors that had a positive association with older people's MWB were taken into account. Momtaz (2010) stated that although widowhood was significantly and negatively associated with psychological well-being, the effect became insignificant when taking religiosity into account.

5. *Association between demographic and socio-economic factors and MWB*

A primary context of older people's MWB is the socio-economic circumstances that older people find themselves in (Higgs et al., 2005). A majority of older people rated financial circumstances as one of the good things that gave their life quality (Gabriel & Bowling, 2004; Bowling & Gabriel, 2007). This positive association between financial status and MWB was consistent over age cohort (Kobayashi, 2015) and for both men and women (Kobayashi, 2015; Zimme & Lin, 1996). Objective indicators such as income are usually significant but weakly correlated with overall MWB (Bowling, 2005a). In contrast, subjective indicators such as better perceived economic status (Ng, 2017) or satisfaction with income (Burton-Jeangros & Zimmermann-Sloutskis, 2016) predicted a stronger effect on older people's MWB. Furthermore, satisfaction with retirement (Alpass, 2000; Li, 2012; Lowis, 2011) or being employed (Momtaz, 2016) were also positively associated with older people's MWB.

Another essential context for MWB is the demographic background in which older people stay. In this review, a higher education level was demonstrated to predict MWB significantly. Comparing with younger people under 60, having qualifications significantly and positively predicted happiness for older people aged 80+, but not significantly for older people aged 60-69 and 70-79 (Cooper, 2011). Moreover, women seemed to benefit from higher education (Zimmer & Lin, 1996). Meanwhile, having religiosity and cultural adherence also significantly and directly predicted better MWB (Park, 2012; Momtaz, 2010; Yoon & Lee, 2007). However, the impact of religiosity was demonstrated to be stronger on the more traditional group (Jang, 2006), and on the oldest cohort (Cooper, 2011; Levin, 1996). Additionally, having more children (Chao, 2012; Silverstein, 2006) or more family members (Park, 2014; Zimmer & Lin, 1996), being in the majority race group (Merz & Consedine, 2009) and living in an urban or less deprived area (García, 2005; Ng, 2017; Sun, 2017) were all significantly associated with better MWB.

By contrast, low education level, less religiosity (female only, Waddell & Jacobs-Lawson, 2010), being in a minority race group (Merz & Consedine, 2009; Sun, 2015) and poor economic status (Chiao, 2012; Margelisch, 2017; Park, 2014; Tajvar, 2008) were all negatively associated with older people's MWB. Nevertheless, being in advanced age or being female were demonstrated to have opposite effects in different studies. Aghamolaei (2010), Kahana (2013), Lim (2017) and Momtaz (2010) suggested that being in advanced age was negatively associated with older people's MWB, while Kadowaki (2015), Merz & Consedine (2009), Ní Mhaoláin (2012) and Park (2012) suggested a positive association between advanced age and MWB. There is some evidence that results varied with the choice of measure of MWB. A negative association between old age and MWB was demonstrated in studies using a measure of positive affect and/or psychological functioning (i.e. SF-36 MCS and WHO-5 well-being scale), whereas a positive association between old age and MWB was found in studies using a measure of life satisfaction (i.e. Life Satisfaction Index and Satisfaction with Life Scale). Waddell & Jacobs-Lawson (2010) and Zimmer & Lin (1996) performed separate analysis on men and women and suggested that older age was positively associated with older men's MWB but negatively associated with older women's MWB. Being female was only recognised to be positively associated with older people's MWB in one study (Kadowaki, 2015). However, the association was very weak and only appeared when adjusting for chronic conditions and functional impairment. Moreover, Kadowaki’s study was based on an unbalanced population where over 67% of the study population were female. In contrast, a negative association was demonstrated in three others, Momtaz (2016), Ng (2017) and Tajvar (2008).

## 4.5 LIMITATIONS

This review had some limitations that should be highlighted. The first limitation is that due to this all-inclusive design, the MWB measures and the factors associated with MWB for every reviewed study were different. Although it would be more accurate to perform a meta-analysis for each factor in order to indicate which factors are more influential, it was not performed in this review due to the following issues.

First, after quality appraisal, only 19 of the 61 reviewed studies met the criteria for meta-analysis analysis, namely being able to: 1) report data to allow for the calculation of an effect size for group differences; 2) perform multivariate analysis on MWB and its determinants; and 3) report the measurement of the association, including confidence intervals (or standard errors) and the probability level (p-value). However, most of the studies adjusted differently for their effect estimates (e.g. age, sex, education, health status and SES), while only 7 of the 20 studies had unadjusted effect estimates. Although pooled effect estimates could be calculated, the conclusions on the power of influence would still be uncertain, since the standard error to calculate the adjusted effects was also unknown. Thus, the best solution was meta-analysing unadjusted studies only. Second, as stated earlier in this review, we investigated five commonly used aspects of MWB in old age: mental well-being, psychological well-being, life satisfaction, quality of life and happiness. For the identified 7 studies: Gale (2011) used the WEMWBS, Heo (2015) and Kadowaki (2015) used the satisfaction with life scale (0-35 point scale), Kahana (2013) used the satisfaction with life scale (modified 0-25 point scale), Kirchmann (2013) used the life satisfaction index, Momtaz (2010) used the WHO-5 Well-being Index, and Thanakwang (2012) used the Thai PWB scale. Without any information on the MWB measures questions, it was not possible to put them on the same scale. For the only two studies that used the satisfaction with life scale 0-35 points scale, Heo (2015) targeted the association between loneliness and MWB while Kadowaki (2015) targeted the association between home care need and MWB. Since the independent variables were different, there is no need to combine their effects on MWB. Despite all these issues, although a meta-analysis was not performed, this was not the aim for this systematic review. The main purpose of the current review was to identify the potential determinants of MWB in later life to be tested in a later chapter (Chapter 7), which was well achieved.

A third limitation is that forest plots only represented unstandardised results – they reported the original findings from the reviewed studies. Although standardised results might indicate a more comparable effect estimate in summary, again, since it was not possible to standardise the MWB measures on one scale, the effect estimate could not be standardised as well. Moreover, the risk of bias in the reviewed studies (see Appendix B:

Review – 1. Determinants of MWB – 1.3 Quality Assessment Results) indicated a relatively moderate bias among the 61 included studies (4 were rated at low risk of bias, 43 were rated at moderate risk of bias and 14 were rated at high risk of bias). The high risk of bias studies suffered from the low representative ability of the entire older population, low comparability of the selected cohorts on the basis of the design or analysis, and lacking an assessment of outcome by using a single subjective measure of MWB (i.e. single question asked about happiness or life satisfaction). Despite these limitations, this review still identified the critical determinants of MWB in late life.

## 4.6 CONCLUSIONS

The main purpose of the current review was to identify the factors associated with MWB in old age. This study inclusively reviewed a large body of the most recent studies, including a wide range of different study design through a mixed-method systematic review approach. While previous reviews of MWB in old age were fraught with challenges due to the multifactorial influence on MWB and the different measures of MWB used, this review tried to combine the findings by categories. Additionally, I also subdivided the categories of related factors by their positive or negative influence on MWB also generated ideas on how to promote MWB in older people's ageing well process. Moreover, this review was also a preliminary work to inform and support my future empirical research on the determinants of older people's MWB (Chapter 7).

The findings from this review also indicated a cumulative effect among factors associated with MWB. This multi-faceted construct tallies with the nature of MWB, which includes subjective accounts of individuals' happiness to fulfilment or satisfaction of a given list of capabilities, functioning or needs.

This review also shone a light on whether the factors associated with older people's MWB change with old age. Although only three studies compared younger-old with older-old, it still generated the possibility for future research on the investigation of the variation in MWB distribution (Chapter 6).

# CHAPTER 5 CONSEQUENCES OF MENTAL WELL-BEING IN COMMUNITY DWELLING OLDER PEOPLE: A SYSTEMATIC REVIEW

## 5.1 INTRODUCTION

Mental well-being (MWB), which refers interchangeably to "positive mental health", "positive well-being" and "well-being", describes both positive functioning (eudaimonic well-being) and positive feelings (hedonic well-being) (Stewart-Brown, 2015, 2018). Its importance is increasingly recognised in a wide range of policies at the local, regional and national level in the UK (Cross-Government Strategy, 2009; Dolan & White, 2007; Layard, 2006). Moreover, it has also been argued that MWB, as a measure of health valuation, should be addressed in consideration of health care resource allocation (Steptoe et al., 2015).

Old age refers to the final stage in the life course of an individual. Not surprisingly, old age is significantly associated with the hazard of mortality, and physical and cognitive decline (Jacob et al., 2011). However, the possibility that MWB is a protective factor against these risks to health has also been increasingly recognised by scholars (Steptoe et al., 2015). Moreover, there is a gap in current research on the added value of MWB to ageing well. This review hence aims to find out the consequences of MWB on older people's ageing well process.

A growing number of prospective epidemiological studies have suggested that MWB predicts lower future mortality (Steptoe et al., 2015), morbidity (Palgi et al., 2015; Collins et al., 2008) and frailty (Gale et al., 2017) for middle and older-aged adults. It also reduces the likelihood of falling (Burns et al., 2012) and the number of hospital inpatient days (Kim et al. (2014) and improves self-rated health (Burns et al., 2014).

Steptoe et al. (2015) used data from the English Longitudinal Study of Ageing (mean age 64.9 years, average follow-up 8.5 years) and compared the proportion of deaths between the lowest and highest quartiles of well-being. They estimated that the highest quartile was associated with a 58% reduction in mortality risk after adjusting for age and gender. After adjusting for physical and mental health, health behaviours and demographic covariates, the highest quartile well-being was still associated with a 30% reduction in risk. Collins et al. (2008) used data from the Survey of Health and Living Status of the Near Elderly and Elderly in Taiwan (mean age 64.1 years, average follow-up 8 years) and suggested that both life satisfaction and happiness were associated with developing fewer mobility limitations, but only for those who had no mobility limitations at baseline.

Burns et al. (2012; 2014) found that positive mental health was a significant predictor of changes in self-rated health over ten years and a stronger protective factor than indices of psychological and physical health on the likelihood of falling of middle and older-aged Australians. However, their research had sample selection bias, wherein the Dynamic Analyses to Optimise Ageing dataset they used, female participants represented 80% of the total sample. Kim et al. (2014) hypothesised from two different dimensions of positive well-being in reducing risk to the health of older Americans (mean age 69.06 years, average follow-up 6 years). They found out that people with a higher purpose in life were more proactive by using preventive health care services. Each unit increased in purpose in life was associated with 17% fewer nights spent in the hospital.

Previous reviews have explored the association between MWB and mortality in studies that combined both healthy and non-healthy adult (aged 18 and above) populations.

Veenhoven (2008) conducted a systematic review of 30 prospective studies on the effect of happiness on longevity and demonstrated that happy people lived longer. Happiness did not predict longevity in sick populations but predicted longevity among healthy populations. In addition, Veenhoven (2008) also found a protective effect of happiness on physical health since happiness did not cure illness but protected against becoming ill when adjusting baseline physical health. Chida & Steptoe (2008) conducted a meta-analysis of 70 prospective studies. They found similar results that the protective effect of positive psychological well-being on longevity was stronger in the healthy adults' population (hazard ratio (HR)=0.82; 95%CI 0.76–0.89; $p<0.001$) than in non-healthy adults' population (HR=0.98; 95%CI 0.95–1.00; $p=0.030$). Moreover, they also found a beneficial age effect of positive psychological well-being on longevity with a stronger protective association in healthy older people aged 60+ (HR=0.74; 95%CI 0.64–0.85; $p<0.001$) than the overall effect in the healthy adults population (HR=0.82; 95%CI 0.76–0.89; $p<0.001$). Evidence from the reviews all demonstrated a protective effect of MWB on longevity. Higher MWB is associated with lower mortality. Moreover, this association is stronger in healthy population than non-healthy population.

Despite this, previous reviews included studies that focused on older people living in nursing homes. There has not been a quantitative review focused on the consequences of MWB for community-dwelling older people. The primary purpose of the current review is, therefore, to identify the consequences of MWB in old age (i.e. reducing the risks to mortality and morbidity). This study will add to the existing literature by 1) including a large body of the most recent studies on MWB (studies using MWB measures considered by most experts such as well-being, positive mental health, life satisfaction, quality of life and happiness); 2) investigating the potential consequences of MWB on reducing risks to health and enhancing ageing well; and 3) conducting a narrative quantitative analysis to compare reviewed studies on the effect of MWB on reducing mortality for community dwelling older people.

The research questions this review intends to address are:

1) What are the consequences of mental well-being in later life?
2) How do previous research studies derive conclusions about MWB consequences of reducing health risks and enhancing ageing well (systematic review)?
3) How do previous research studies derive conclusions about MWB consequences of reducing mortality (narrative quantitative analysis)?

## 5.2 METHODS

PRISMA (Moher et al. 2015) guidelines were used as a framework. Prior to formulating the protocol for the review, I (JW) conducted a scoping review to ensure that a systematic review or meta-analysis pertaining to the research questions had not been previously published and registered. The review protocol was registered on PROSPERO (Registration number: CRD42016048147).

### 5.2.1 SEARCH STRATEGY

The general bibliographic databases searched were PubMed, Ovid MEDLINE, PsycINFO, Scopus and Cochrane Library. The search terms were {("Well Being" OR wellbeing OR "well-being" OR “positive mental health” OR "life satisfaction" OR "quality of life" OR happiness) AND (mental OR positive) AND (aging* OR ageing* OR "older people" OR "older adult*" OR pensioner* OR elderly OR geriatric* OR retired)} in Title/Abstract. The reference lists of the retrieved articles and review papers were searched and appraised to identify potentially relevant articles. JW screened 100% of abstracts and full-text articles, and a second reviewer – MD – independently screened 50% of abstracts and full-text articles as a reliability check.

*Inclusion criteria*

1) Prospective studies design;
2) Published articles in peer reviewed journals;
3) English language full-length publication;
4) Published from January 1990 to current day of searching (15 June 2017);
5) Populations aged 60 or above (or have a separate analysis on 60 or above) according to the UN's use of old age (UN, 2001);
6) Include a validated measure of MWB;
7) Include a community-based population;
8) Focus on the consequences of MWB in later life;
9) Focus on MWB rather than mental illness;
10) Explain an association between MWB and its estimated consequences.

*Exclusion criteria*

1) Books and reviews of books;
2) Well-being or quality of life measures that only related to/measured physical well-being/quality of life or social well-being/quality of life;
3) Institutionalised population only, or studies that focus on relocation;
4) Patients/older people with specific disease;
5) Mortality based on death caused by suicide, injury or accident and those unnatural deaths;
6) Protocols, or study design and methodology.

### 5.2.2 DATA EXTRACTION AND QUALITY ASSESSMENT

All data extraction was conducted by a single reviewer (JW). A data extraction table (see Appendix B: Review – 2. Consequences of MWB – 2.1 The summarised findings from reviewed papers) for the systematic review was developed which includes the author (publication year); statistical methods used; cohort size (response rate); outcome variables (follow-up years); MWB measurement; covariates; adjustments; comparison and results of finding. The studies included in the forest plots recorded: author (year of publication); population (sample size, male/female); country; follow-up duration (years); MWB measurement; covariates included in the analysis; brief results as effect size (hazard ratio (HR) or relative risk (RR)) with variance estimates (95% confidence intervals (CI)). When studies divided participants into more than three groups by MWB factor (e.g., quartiles or quintiles; happy, moderately happy or unhappy), I extracted the HRs or RRs, comparing the highest with the lowest (reference group) positive well-being levels.

Articles adhering to the inclusion criteria were quality assessed for final inclusion in the review. The quality assessment (QA) was undertaken using the Newcastle Ottawa Scale (NOS) for cohort studies (Well et al., 2012). Each study was rated on three categories on a 9-point scale: 1) selection (maximum 4 points); 2) comparability (maximum 2 points); and 3) outcome (maximum 3 points). Due to the limited number of studies available, I did not exclude any study in the systematic review based on QA score. A summary results table of QA, which included author detail, year of publication, risk of bias and QA scores, was presented in Appendix B: Review – 2. Consequences of MWB – 2.2 Quality assessments results.

### 5.2.3 DATA SYNTHESIS

A narrative quantitative analysis of the effect of MWB on mortality was also performed. Hazard ratio (HR) and relative risk (RR) were used as the measures of effect size in the forest plots. HR is frequently interpreted as RR. However, HR and RR are used to measure different types of outcomes, and models used to calculate them have different assumptions. One of the main differences is that RR only focuses on the occurrence of the event at the end of the period. The time that the event occurs is less important when calculating RR. In contrast, HR takes into account both the total number of events at the end of the period and the time each event occurs. Nevertheless, with limited follow-up duration, the RR derived by a Cox model and the HR could be more or less equal (Stare & Maucort-Boulch, 2016). In practice, they have been combined previously in a meta-analysis (Chida & Steptoe, 2008). However, the odds ratio (OR) is very much a different estimate from HR or RR. Studies that only reported ORs and raw data insufficient to calculate the HR or RR would not be included in the forest plots. Furthermore, the study that used a method that could not be compared (a probit model) and the study that did not report a mortality rate were excluded from the forest plots.

## 5.3 RESULTS

Figure 27 below presents the flow diagram for conducting this systematic review. The search terms identified a total of 18,078 studies. After removing duplicates, 14,202 citation titles and abstracts were screened for inclusion, of which 37 articles were selected for full-text eligibility assessment. A large number of exclusion papers at the screening stage is due to the same search terms used to conduct two parallel reviews. Whenever a title/abstract was screened, it was purposely screened for both reviews (i.e. determinants and consequences). Of the 37 full-text articles, 11 articles fulfilled the inclusion criteria. There was an acceptable level of agreement between reviewers (agreement=99.99%). Two articles identified by hand search were added. In total, 13 papers were eligible for the review (see Appendix B: Review – 2. Consequences of MWB – 2.1 The summarised findings from reviewed papers for a description of included studies).

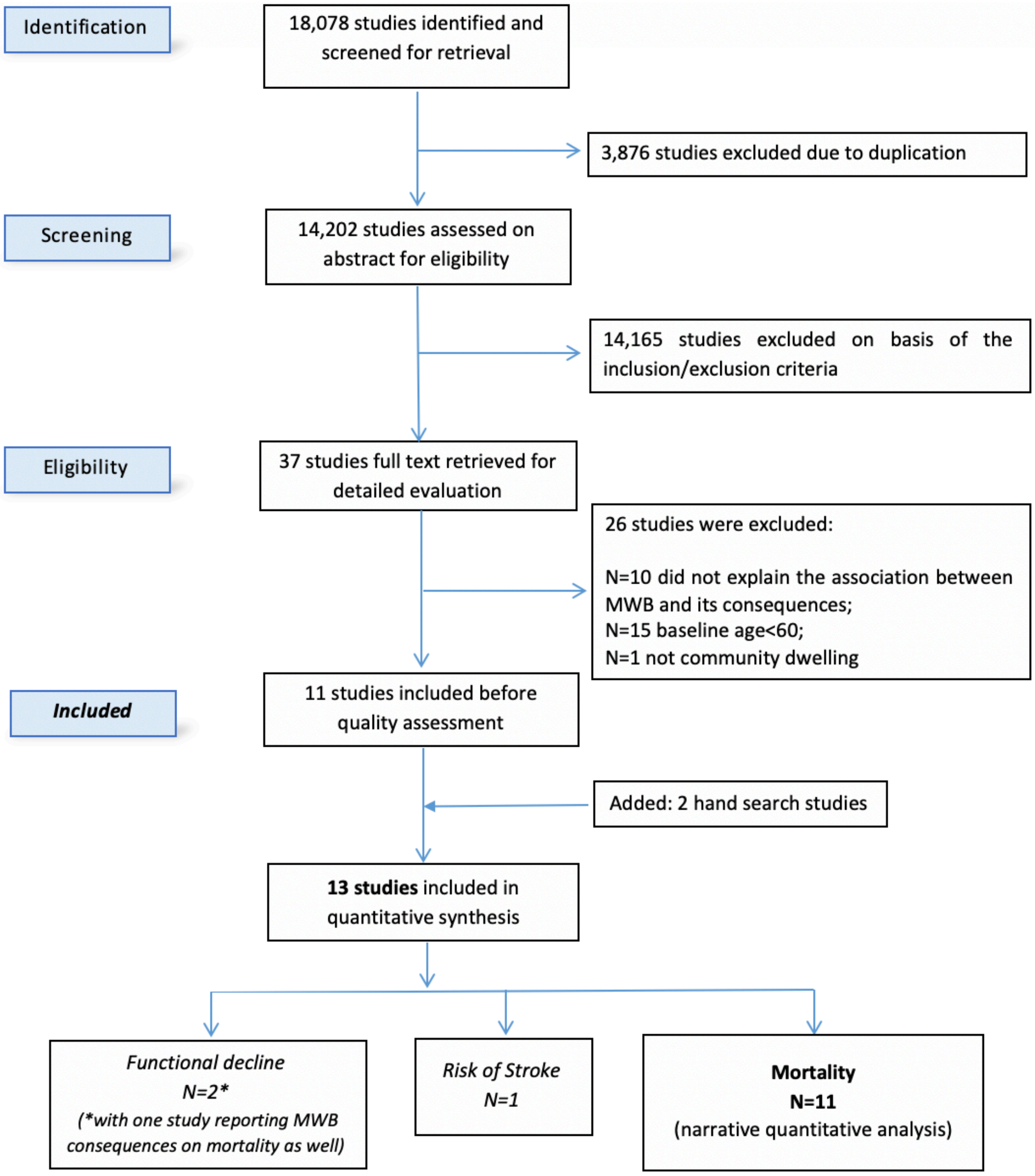



*Figure 27. Flow diagram of the review*

### 5.3.1 MEASURES OF MWB

*Mental well-being*

MWB, by definition, comprises both positive feelings and positive functioning (Stewart-Brown, 2018a, p. 504). In this review, MWB is defined as the combination of hedonic well-being (Mroczek & Kolarz, 1998) and the psychological (Ryff, 1989; Ryff & Keyes, 1995) and social aspects of eudaimonic well-being (Keyes, 1998) (Keyes, 2013). The constructs of the MWB measures used in the reviewed studies are summarised in Table 9 below.

*Table 9. Measures of MWB in reviewed studies*

| Constructs of Mental Well-being (measures used in reviewed studies) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Measures** | **Number of studies** | **Positive affect** | **Happiness** | **Satisfaction of life** | **Psychological functioning** | **Interpersonal relationships** | **Purpose in life** | **Vitality** |
| Positive affect | 4 | √ | √ | √ | | | | |
| Life Satisfaction Scale/Index | 4 | √ | √ | √ | | | | |
| SF-12 MCS | 2 | √ | | | √ | √ | | √ |
| Ryff PWB scale | 1 | | | | √ | √ | √ | |
| Subjective happiness | 1 | | √ | | | | | |
| Subjective life satisfaction | 1 | | | √ | | | | |

### 5.3.2 STUDY CHARACTERISTICS AND QUALITY

Thirteen studies, which covered countries from Asia, Europe and America on the consequences of MWB in old age, satisfied the inclusion criteria. The average follow-up period was 8.77 years (range: 2 years – 20 years, median: 8 years), and the mean sample size was 2523.36 (range: 505 – 5703, median: 2327.5) (see Table 10 below).

*Table 10.Characteristics of the included studies*

| No. | Study | Country | Sample size | Follow-up (yrs) |
|---|---|---|---|---|
| 1 | *Andrew (2012)* | *Canada* | *5703* | *5* |

| | | | | |
|---|---|---|---|---|
| 2 | *Blazer & Hybels (2004)* | *US* | *3673* | *10* |
| 3 | *Bowling & Grundy (2009)* | *UK* | *1384* | *20* |
| 4 | *Kimm (2012)* | *South Korea* | *1939* | *11.8* |
| 5 | *Koopmans (2010)* | *Netherlands* | *861* | *15* |
| 6a | *Li (2013)* | *UK* | *690* | *14* |
| 6b | *Li (2013)* | *China (Taiwan)* | *1438* | *14* |
| 7 | *Mete (2005)* | *China (Taiwan)* | *3611* | *7* |
| 8 | *Ostir (2000)* | *US* | *2282* | *2* |
| 9 | *Otero-Rodríguez (2010)* | *Spain* | *2373* | *4* |
| 10 | *Sadler (2011)* | *Denmark* | *3966* | *9* |
| 11 | *Tsai (2007)* | *China (Taiwan)* | *4424* | *3* |
| 12 | *Hirosaki (2013)* | *Japan* | *505* | *2* |
| 13 | *Ostir (2001)* | *US* | *2478* | *6* |
| mean | | | *2523.36* | *8.77* |
| median | | | *2327.5* | *8* |
| sd | | | *1554.33* | *5.57* |
| se | | | *415.41* | *1.49* |

All thirteen articles were quality assessed using the NOS (Well et al., 2012). Each study was rated on eight items within three categories on a 9-point scale: 1) selection (maximum 4 points); 2) comparability (maximum 2 points); and 3) outcome (maximum 3 points). A study was given a maximum of one point for each numbered item within the selection and exposure categories. A maximum of two points was given for comparability. In general, high quality was given to those who have an overall QA score of 8 points and above. The scores within each of the three categories also need to satisfy: 3 or 4 points in selection domain and 1 or 2 points in comparability domain and 2 or 3 points in outcome/exposure domain. Moderate quality was given to those who have an overall QA score of 4-7 points with the satisfaction of scores as 2 points in selection domain and 1 or 2 points in comparability domain and 2 or 3 points in outcome/exposure domain. Low quality was given to those who have an overall QA score of 4 points and under. The scores within each of the three categories also need to satisfy: 0 or 1 point in selection domain or 0 points in comparability domain or 0 or 1 point in outcome/exposure domain. 0.5 points were given to those satisfied partially with the assessment items. Figure 28 below presents a summary of the QA, and the scores given to each of the eight items. The details of the QA scores attached to each item was summarised in Appendix B: Review – 2. Consequences of MWB – 2.2 Quality assessments results. An overall low rating (QA score 4 and under) was given to two studies (2/13 (15.38%)); Andrew (2012) and Mete (2005) both had a QA score of 4. Andrew (2012) was given 'low' ratings in the sub-sections 'comparability' and 'outcome', meaning the assessment of outcome reported was not clear and comparable (no reported mortality rate) and might suffer from severe bias. Mete (2005) was given 'low' ratings in the sub-section 'comparability', meaning the study result (probit model) could not be compared with other studies. Despite all that, most of the reviewed studies, 10/13 (76.92%), had an overall moderate rating of QA score 4-7. An overall high rating (QA score 8 and above) was given to only one study 1/13 (7.69%), Ostir (2000). (See Figure 28 below for a summary of QA and see Appendix B: Review – 2. Consequences of MWB – 2.2 Quality assessments results).

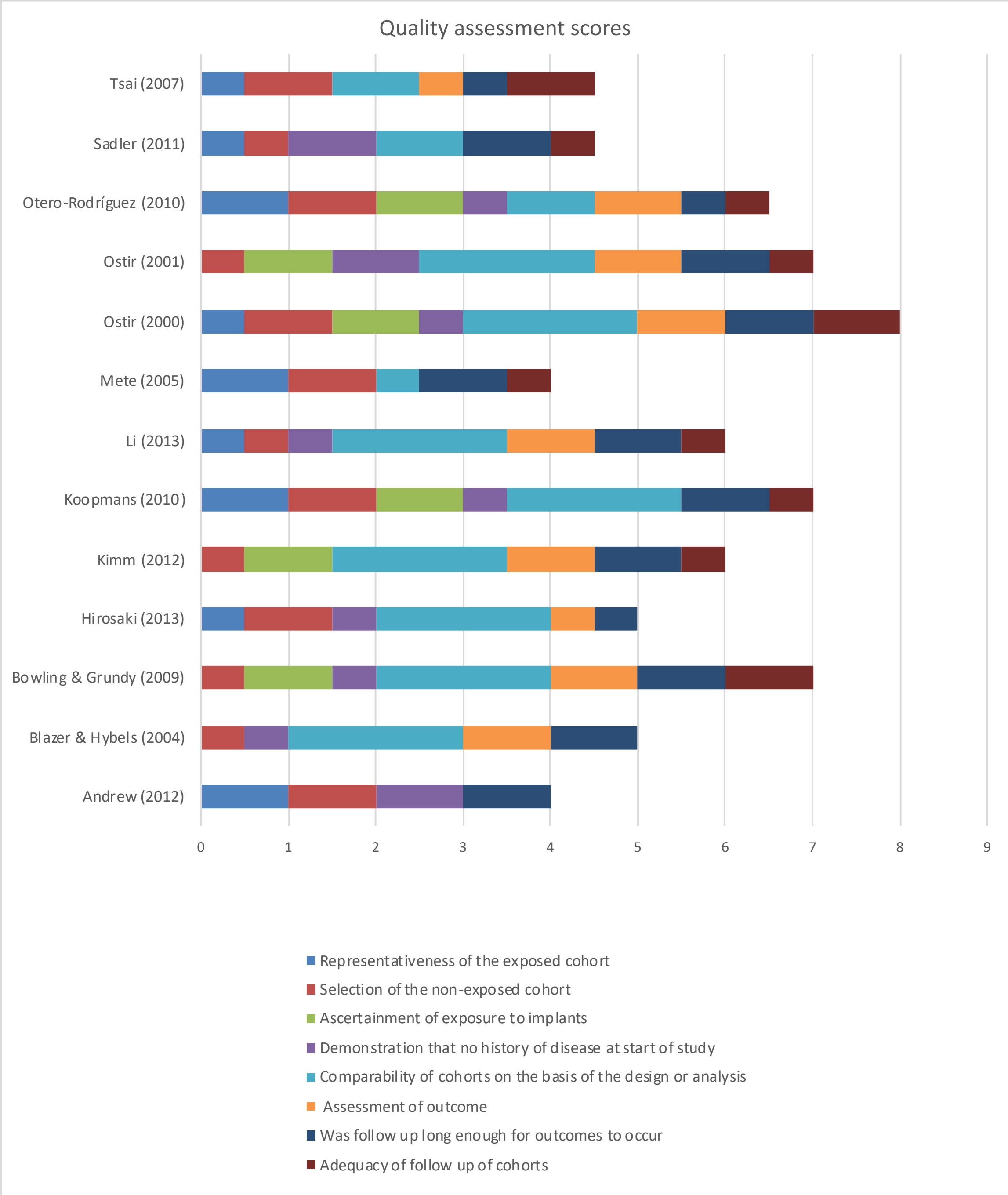



*Figure 28. Quality assessment scores*

### 5.3.3 STUDY RESULTS AND NARRATIVE QUANTITATIVE REVIEW

Results from the 13 included articles provided evidence of consequences of MWB on reducing risks to health. MWB demonstrated a significant protective effect on reducing the risk of stroke (1 article; Ostir, 2001) and functional decline (2 studies; Hirosaki, 2013 and Ostir, 2000). In addition, moderate evidence suggested that MWB was associated with increased longevity (11 studies). One study, Ostir (2000) reported MWB consequences both on reducing the risk of functional decline and lower mortality. Although variations appeared across reviewed studies due to data availability, physical health status and socio-demographic circumstances were generally controlled. A summary of the reviewed studies is presented in Appendix B: Review – 2. Consequences of MWB – 2.1 The summarised findings from reviewed papers.

*Lower risk of functional decline – at the 2-year follow-up*

Ostir (2000) and Hirosaki (2013) both focused on older people aged 65+ who had no limitations on their activities of daily living (functional limitation) at baseline. They both suggested that positive affect was associated with a significantly lower risk of functional decline at the 2-year follow-up. Ostir (2000) sampled from 2,282 Mexican-Americans and found that baseline positive affect score was associated with a lower risk of functional limitation at follow-up (OR=0.94, 95%CI 0.89-0.99). Hirosaki (2013) sampled from 505 older residents in a Japanese town. They reported moderate evidence on this association that positive affect significantly predicted a lower risk of functional limitation independent of negative affect, age, partner status, past medical history and higher-level functional capacity with an OR of 0.66 (95%CI 0.50–0.89, p=0.005). In contrast, negative affect did not predict a functional decline.

*Lower risk of stroke*

Ostir (2001) presented a 6-year prospective study of 2,478 older Americans aged 65+ who reported no history of stroke at baseline. The CES-D positive affect subscale was used, and the risk of stroke was assessed by the number of physician-diagnosed strokes and the number of deaths in which stroke was the cause of death. The results showed that only positive affect demonstrated a significant inverse association with stroke incidence (RR=0.74, 95%CI 0.62–0.88), while negative affect had a nonsignificant association with stroke incidence. Besides, this association was significant for both men and women, from white and black ethnic backgrounds. The study was adjusted for socio-demographic circumstances, behavioural factors related to a healthy lifestyle (i.e. smoking status and alcohol use), and baseline negative affect.

*Lower risk of mortality*

Eleven of the reviewed articles (12 cohorts) focused on the association between MWB and mortality. The reviewed studies are summarised by the different MWB perspectives they focused, eudaimonic and hedonic perspectives of MWB (a review of commonly used measures of MWB that separated by these two perspectives was previously outlined in Chapter 3). Otero-Rodríguez (2010) and Tsai (2007) all used SF-36 MCS as a measure of MWB (covered both eudaimonic and hedonic perspectives of MWB). SF-36 was scored on a 0-100 points scale. They both concluded that a 10-point decrease from baseline MCS score was a significant predictor of mortality (up to 4 years and up to 3 years consequently) with socioeconomic characteristics and physical health controlled.

Andrew (2012) indicated that psychological well-being (measured by Ryff's PWB scale that falls into the eudaimonic perspective of MWB) predict five-year mortality independent of frailty, age, sex, education and mental health (measured by Mental Health Index-5 that indicating a positive/negative feeling). However, this association no longer hold statistical significance when baseline cognitive status (measured by the Mini-Mental

State Examination) had been taken into account. Nonetheless, their study did not report a mortality rate and hence could not be included in the narrative quantitative analysis.

Blazer & Hybels (2004) investigated the predictive ability of low positive affect (a measure of MWB that falls into the hedonic perspective of MWB) on mortality over 10 years with cognitive and functional health, and demographic & socio-economics circumstances controlled. The odds of mortality for low positive affect (measured by the four items: felt as good as other people, felt hopeful about the future, felt happy, and enjoyed life) was 1.11 (95% CI=1.04–1.18, P<0.001). Bowling & Grundy (2009) indicated that life satisfaction (measured by the Neugarten Life Satisfaction Scale score) was a protective factor of mortality, particularly among females and people aged 85+, even when health status and socio-demographic circumstances were controlled. Kimm (2012) also found that lower life satisfaction (measured by Life Satisfaction Index tertiles) predicted a significantly higher risk of all-cause mortality for both male and female. Their study controlled socio-economics, health behaviours (smoking and drinking), physical and mental health. Koopmans (2010) found that happiness predicted lower mortality after controlling for demographic & socio-economics circumstances, but this association lost statistical significance after adjusting physical activity and chronic diseases.

One study, Li (2013), included two different cohorts (sampled from UK and China-Taiwan databases). Higher life satisfaction (measured by Life Satisfaction Index -Z scale) was found to be significantly associated with a lower risk of 14-years mortality after adjusting demographic & socio-economics and social engagement variables in both the UK and Taiwan cohorts. When further adjusting for physical and mental health, life satisfaction remained significantly associated with a lower risk of mortality in the UK cohort, but not in Taiwan cohort. Mete (2005) also focused on the same Taiwanese population as in Li (2013) (i.e. same survey datasets and same baseline time point but followed up to 7 years). However, there is a slightly contradictory finding in Mete's study, where he indicated that life satisfaction was significantly associated with a lower risk of mortality even after controlling health status and other socioeconomic characteristics. Nonetheless, Mete used a probit model (results reported as the marginal effects for being alive) to predict this association which is much different from the Cox proportional hazards model that commonly used in survival analysis (also used by Li, 2013).

Figure 29 below presents a graphical summary of the sample size (blue bars), number of deaths (grey bars), mortality rate (the percentages) and years of follow-up of these 11 articles (12 cohorts). 'Li (2013) a' represents the UK cohort and 'Li (2013) b' represents the China-Taiwan cohort. These 12 cohorts involved an average of 2,695 participants (range: 690-5703; SE=452) and followed-up for an average of 9.57 years (range: 2-20; SE=1.61). The mortality rate increased (from 4.7% to 87.5%) as the follow-up period increased (from 2 years to 20 years).

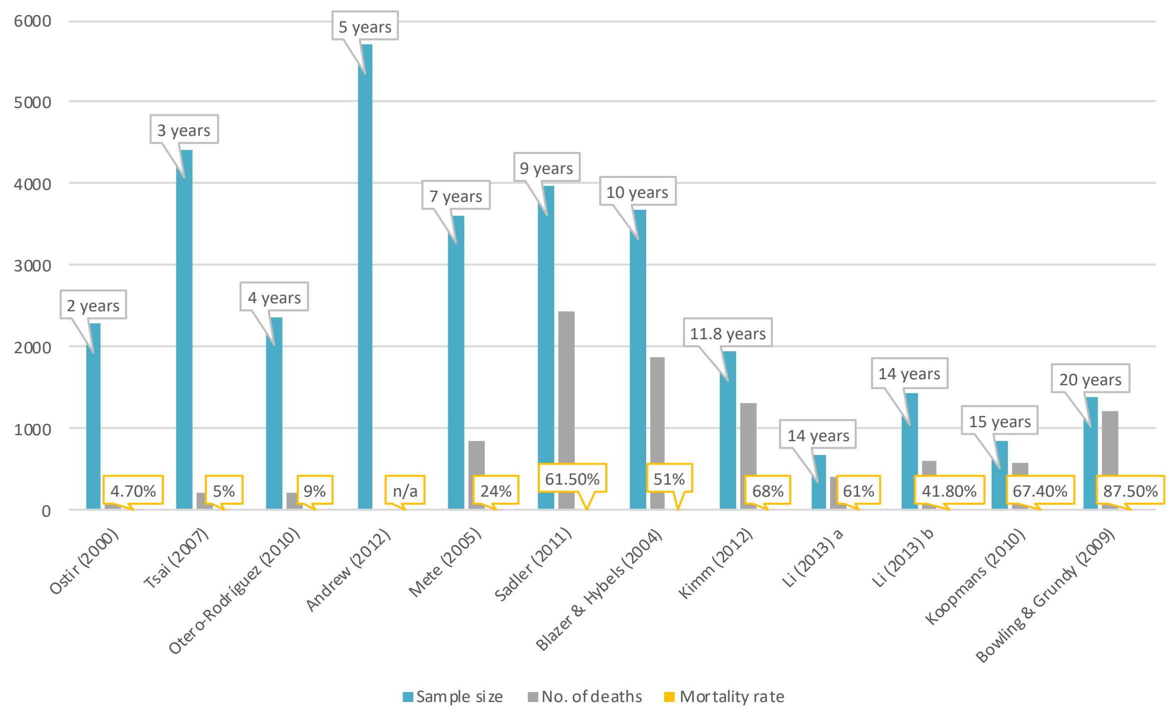



*Figure 29. Sample size, mortality rate and years of follow-up*

Table 11 below details the 11 prospective studies reviewed (also see Appendix B – 2. Consequences of MWB – 2.3 A summary of reviewed papers on MWB consequences on mortality). The results were separately presented in different rows if a separate analysis was performed. Those without a significant result were left blank. All of the 11 articles demonstrated a significant positive effect of higher MWB on mortality rate when adjusted for demographics (age, sex, education, ethnicity) and socio-economic factors. Three studies lost their significance when further adjusted for cognitive health (Andrew, 2012), chronic disease and physical activities (Koopmans, 2010), and physical health, chronic disease and mental health (Li, 2013 on Taiwanese sample only). However, different conclusion was found in other studies. Blazer & Hybels (2004) and Sadler (2011) all found that the association between MWB and mortality remained statistically significant even when cognitive health was taken into account. There is a possibility that the contradictory results were due to the different aspects of MWB studied. Andrew (2012) used Ryff's PWB scale that focused on the eudaimonic perspective of MWB, while Blazer & Hybels (2004) used positive affect and Sadler (2011) used a single life satisfaction question that all focused on the hedonic perspective of MWB.

*Table 11.Prospective studies investigating the effect of MWB on mortality*

| No. | Study | Population (Sample size; Male/Female) | Country | Follow-up | MWB Measurement | Covariates | Results/Effect Size (HR/RR, 95%CI) |
|---|---|---|---|---|---|---|---|
| 1 | *Andrew (2012)* | *N=5703 mf* | *Canada* | *<=5 years* | ***PWB*** *(Ryff scale)* | *Ag, Sx, Edu, Frailty, MH, and Cog* | - |
| 2 | *Blazer & Hybels (2004)* | *N=3673 mf* | *US* | *<=10 years* | ***Positive affect*** *(Positive-4 of CES-D)* | *Ag, Sx, Edu, Eth, MS, SES, Cog, Func* | *per unit low positive affect* ***(HR 1.12, 95%CI 1.05–1.18, P=0.000)*** |
| 3a | *Bowling & Grundy (2009)* | *N=1384 mf* | *UK* | *<=20 years* | ***Life Satisfaction*** *(Neugarten's LS scale)* | *Ag, Sx, ADL,SES, MH* | *per unit increase in life satisfaction* ***(HR 0.985, 95%CI 0.970–0.999, P=0.040)*** |
| 3b | *Bowling & Grundy (2009)* | *N=965 f* | *UK* | *<=20 years* | ***Life Satisfaction*** *(Neugarten's LS scale)* | *Ag, Sx, ADL,SES, MH* | *per unit increase in life satisfaction* ***(HR 0.979, 95%CI 0.062–0.996, P=0.015)*** |
| 3c | *Bowling & Grundy (2009)* | *N=629 (85+)* | *UK* | *<=20 years* | ***Life Satisfaction*** *(Neugarten's LS scale)* | *Ag, Sx, ADL,SES, MH* | *per unit increase in life satisfaction* ***(HR 0.980, 95% CI 0.961–1.000, P=0.045)*** |
| 4a | *Kimm (2012)* | *N=821 m* | *South Korea* | *<=11.8 years* | ***Life satisfaction*** *(Neugarten's LSI-A)* | *Ag, Sx, Edu, CD, Sm, Al, MH, ADL, IADL* | *Unsatisfied* ***HR 1.42 (95% CI, 1.11-1.83)*** |
| 4b | *Kimm (2012)* | *N=1118 f* | *South Korea* | *<=11.8 years* | ***Life satisfaction*** *(Neugarten's LSI-A)* | *Ag, Sx, Edu, CD, Sm, Al, MH, ADL, IADL* | *Unsatisfied* ***HR 1.51 (95% CI, 1.18-1.92)*** |
| 5a | *Koopmans (2010)* | *N=861 mf* | *Netherlands* | *<=15 years* | ***Happiness*** *(subjective happiness )* | *Ag, Sx, Edu, MS, SES* | ***Happy HR 0.77, 95%CI 0.63–0.95, P=0.01*** |
| 5b | *Koopmans (2010)* | *N=861 mf* | *Netherlands* | *<=15 years* | ***Happiness*** *(subjective happiness )* | *Ag, Sx, Edu, MS, SES, CD, Sm, PA* | - |
| 6a | *Li (2013)* | *N=690 mf* | *UK* | *<=14 years* | ***Life satisfaction*** *(LSI-Z)* | *Ag, Sx, MS, SES* | *per unit increase in LSI* ***(HR 0.990, 95%CI 0.985-0.995, p<0.001)*** |
| 6b | *Li (2013)* | *N=690 mf* | *UK* | *<=14 years* | ***Life satisfaction*** *(LSI-Z)* | *Ag, Sx, MS, SES, Sm, CD, social activity, PH, MH* | *per unit increase in LSI* ***(HR 0.993, 95%CI 0.987-0.999, p=0.028)*** |
| 6c | *Li (2013)* | *N=1438 mf* | *China (Taiwan)* | *<=14 years* | ***Life satisfaction*** *(LSI-Z)* | *Ag, Sx, MS, SES* | *per unit increase in LSI (HR* ***0.994, 95%CI 0.992-0.999, p=0.022)*** |
| 6d | *Li (2013)* | *N=1438 mf* | *China (Taiwan)* | *<=14 years* | ***Life satisfaction*** *(LSI-Z)* | *Ag, Sx, MS, SES, Sm, CD, social activity, PH, MH* | - |
| 7 | *Mete (2005)* | *N=3611 mf* | *China (Taiwan)* | *<=7 years* | ***Life satisfaction*** *(LSI)* | *Ag, Sx, Eth, MS, SES, Edu, PH, ADL, CD* | *An individual at the* ***75th percentile of the LSI*** *distribution is* ***3.5% more likely to be alive*** *compared to an individual at the* ***25th percentile*** |
| 8 | *Ostir (2000)* | *N=2282 mf* | *US* | *<=2 years* | ***Positive affect*** *(Positive-4 of CES-D)* | *Ag, Sx, MS, SES, Edu, CD, BMI, Sm, Al, NA* | ***Low positive affect (OR 2.39; 95%CI 1.22-4.68)*** *significantly increase risk for mortality compared to High positive affect* |
| 9a | *Otero-Rodríguez (2010)* | *N=2373 mf* | *Spain* | *<=4 years* | ***HRQoL*** *(SF-36 baseline MCS)* | *Ag, Sx, MS, SES, Edu, CD, BMI, Sm, Al, baseline HRQoL, PA, change in PCS* | - |
| 9b | *Otero-Rodríguez (2010)* | *N=2373 mf* | *Spain* | *<=4 years* | ***Changes in MCS in 2 years before study*** *( SF-36)* | *Ag, Sx, MS, SES, Edu, CD, BMI, Sm, Al, baseline HRQoL, PA, change in PCS* | ***Decrease of >10 points in the MCS (HR 1.60; 95% CI 1.12-2.28, p<0.05)*** *is associated with 60% increase in mortality compared to Changes of -5~5 points in the MCS* |
| 10 | *Sadler (2011)* | *N=3,966 twins* | *Denmark* | *<=9 years* | ***Life satisfaction*** *(single subjective question)* | *Ag, Sx, CD, Cog* | *per standard deviations increase in life satisfaction* ***(HR 0.87, 95%CI 0.83 – 0.91, p=0.000)*** *was associated with a reduction in mortality risk* |
| 11 | *Tsai (2007)* | *N=4424 mf* | *China (Taiwan)* | *<=3 years* | ***HRQoL*** *(Chinese SF-36)* | *Ag, Sx, CD, Sm, fall, utilization of inpatient and emergency services in last 3 months* | *A 10-point decrease from baseline MCS score* ***(RR 1.16, 95%CI 1.01–1.34, p = 0.036)*** *was a significant predictor of mortality* |

Covariates: Ag=age; Sx=sex; CD=chronic disease; Edu=education; MH=mental health; Cog=cognitive health; Eth=ethnicity; MS=marital status; Sm=smoking; Al=alcohol; SES=socio-economic status; PA=physical activities; PH=physical health; NA=negative affect; Func=functional impairment

Most of the reviewed studies reported their results on the positive association between MWB and mortality by HR category, HR unit or RR, and OR group or OR unit. Only one study, Mete (2005), reported their results as per unit increase on the probit scale (see

Figure 30 below). Nevertheless, due to the differences in the ways included studies presented their results, it was not appropriate to include them in a meta-analysis (see Appendix B – 2. Consequences of MWB – 2.3 A summary of reviewed papers on MWB consequences on mortality for the reasons for not performing meta-analysis).

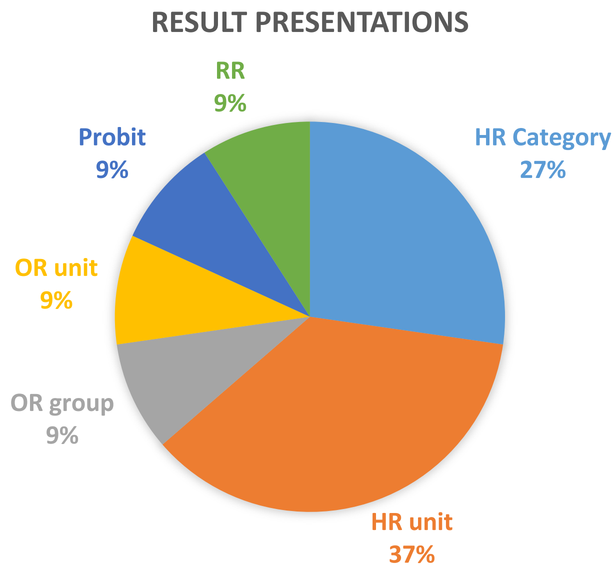
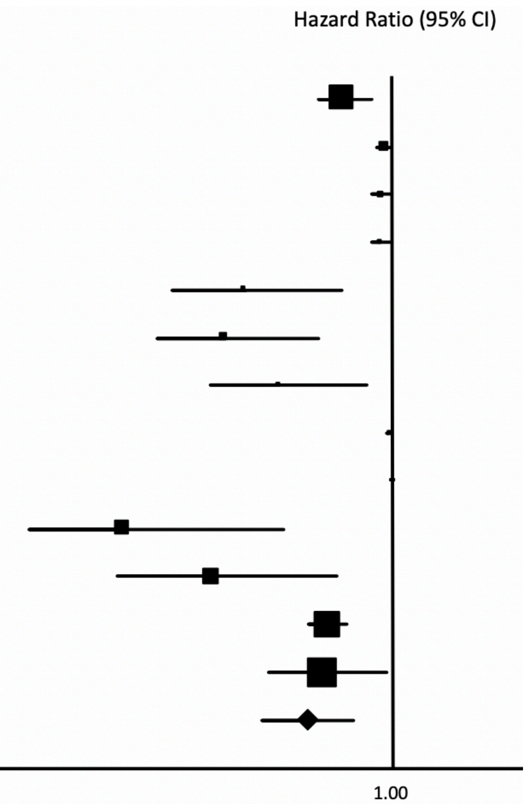



*Figure 30. Results presentation*

Despite this, a narrative quantitative analysis on the effect of MWB on mortality was performed. The narrative quantitative analysis did not standardise the different MWB measures used in the included studies and the differences in the ways included studies presented their results. As mentioned in the methods section, I used the HR and RR as the measures of effect size in the forest plots (see Figure 31 below). For studies that did not report either an HR or RR, raw data on the number of deaths during follow-up was used to calculate the RR. In total, I hand calculated the RR for two studies – Koopmans (2010) and Ostir (2000). The number of deaths during follow-up in Koopmans (2010) was received after direct contact with the author. I also extracted the RR of Ostir (2000) by comparing the highest with the lowest (reference group) positive well-being levels. For studies that included different cohorts (separated sample by gender, age or country), their results were also treated separately in the overall combined HR/RR analysis (see Figure 31 below).

| No. | Study | Sample size | HR/RR | 95%CI |
|---|---|---|---|---|
| 1 | *Blazer & Hybels (2004)* | *3673* | *0.90* | *0.85 – 0.96* |
| 2a | *Bowling & Grundy (2009)* | *1384* | *0.99* | *0.97 – 1.00* |
| 2b | *Bowling & Grundy (2009)* | *965* | *0.98* | *0.96 – 1.00* |
| 2c | *Bowling & Grundy (2009)* | *629* | *0.98* | *0.96 – 1.00* |
| 3a | *Kimm (2012)* | *821* | *0.70* | *0.55 - 0.90* |
| 3b | *Kimm (2012)* | *1118* | *0.66* | *0.52 - 0.85* |
| 4 | *Koopmans (2010)* | *861* | *0.77* | *0.63 – 0.95* |
| 5a | *Li (2013)* | *690* | *0.99* | *0.99 – 1.00* |
| 5b | *Li (2013)* | *1438* | *1.00* | *(1.00 – 1.00)* |
| 6 | *Ostir (2000)* | *2282* | *0.45* | *0.26 – 0.78* |
| 7 | *Otero-Rodríguez (2010)* | *2373* | *0.63* | *0.44 – 0.89* |
| 8 | *Sadler (2011)* | *3966* | *0.87* | *0.83 – 0.91* |
| 9 | *Tsai (2007)* | *4424* | *0.86* | *0.75 – 0.99* |
| | **Total** | **24624** | **0.83** | **0. 73 – 0.92** |




Note:

2a represents the total sample in Bowling & Grundy (2013), where 2b represents the cohort with females only and 2c represents the cohort with the sample aged 85+ only.

3a represents the cohort with males only and 3b represents the cohort with females only in Kimm (2012).

5a represents the UK cohort and 5b represents the Taiwan cohort in Li (2013).

*Figure 31. The effect of MWB on mortality (narrative analysis)*

An HR or RR could not be calculated for two studies. Andrew (2012) did not report the mortality rate, and Mete (2005) used a probit model (unable to compare with HR per unit measure). As such, these studies were removed from the overall combined HR/RR analysis.

As shown in Figure 31 above, the overall combined HR was 0.83 (95%CI 0.73-0.92), indicating a protective effect of MWB on mortality risk. Larger symbols (square) reflected studies with greater sample sizes. The effect of MWB (measured by HR/RR) varied a lot due to the differences in which included studies presented their results. For studies that HR presented by the unit increase on an MWB scale (Blazer & Hybels, 2004; Bowling & Grundy, 2009; Li, 2013), the effect of MWB was relatively small (HR/RR close to 1). However, for those studies that divided participants into more than three groups by MWB factor (Kimm, 2012; Koopmans, 2010; Ostir, 2000; Otero-Rodriguez, 2010) and compared the highest with the lowest (reference group) MWB levels, the effect of MWB was relatively large (HR/RR away from 1).

In addition, most of the studies measured MWB on a scale. However, two studies (Otero-Rodríguez, 2010 and Tsai, 2007), used changes of SF-36 MCS from baseline. Otero-Rodríguez (2010) found that baseline SF-36 MCS showed no significant association with mortality. However, after controlling for the main confounders and changes in SF-36 PCS, changes in SF-36 MCS displayed a positive dose-response relationship with mortality. A decrease of more than 10 points in the SF-36 MCS was associated with a 60% increase in mortality (HR=1.60; 95%CI 1.12-2.28). Similarly, Tsai (2007) demonstrated that a 10-point decrease from baseline SF-36 MCS score was a significant predictor of mortality (RR=1.16, 95%CI 1.01–1.34, p=0.036).

## 5.4 DISCUSSION

The results from the narrative quantitative analysis supported the idea that MWB could lead to a significant inter-person difference in longevity. The overall combined HR 0.83 (95%CI 0.73-0.92) was very similar to the results in a meta-analysis (Chida & Steptoe, 2008). Chida & Steptoe (2008) found a protective effect of MWB on mortality in the healthy population (HR=0.82; 95%CI 0.76–0.89; p<0.001) and in healthy older people aged 60+ (HR=0.74; 95%CI 0.64–0.85; p<0.001) when compared to the overall effect. However, Steptoe et al. (2015) also indicated that MWB might be "a marker of underlying biological processes or behavioural factors that are responsible for the effect on survival" (p.646) where psychoneuroimmunology may also explain the mechanism between MWB and mortality. The results from the narrative quantitative analysis raised the possibilities that MWB was associated with reduced risk to mortality in old age, although whether there is a direct or an indirect association between MWB and mortality is unclear.

Nonetheless, this review added to the current review on MWB consequences with evidence of MWB in association with reduced risk to functional decline and stroke in old age. However, this review failed to find evidence of MWB in association with reduced cost (i.e. reducing the needs of care, reducing hospital inpatient days) of MWB in old age. The quantitative analysis of the consequences of MWB in Chapter 7, therefore, will focus on the consequences of MWB in later life beyond associations with mortality. It will consider MWB consequences from the aspects of ageing well, mainly focusing on physically ageing well (represented by the SF-12 Physical Component Summary (PCS) in this PhD). The analysis for MWB consequences will focus on the direct effect of MWB on physically ageing well and adjust for mental illness, demographic & socio-economics characters and baseline SF-12 PCS. Moreover, it also aims to examine the indirect effect of MWB by investigating whether MWB could mediate and/or moderate the association between later-life risk factors (measured by self-assessed poor health and controlled other covariates that concluded from the previous review in Chapter 4) and SF-12 PCS. The longitudinal and bidirectional associations between physical health and MWB will also be investigated.

The systematic review had several limitations. Firstly, there was a possibility of respondent bias arising from the knowledge of ill health and therefore impending death. However, this bias could be reduced as the interval between assessment of MWB and ascertainment of outcome increases. In general, prospective studies with larger sample size and longer follow-up periods were considered to have stronger statistical power. Due to the small number of articles included in the review and the target population (older people), the number of studies that had both a large sample size and a long follow-up period was small. In other words, the statistical effects of the narrative quantitative analysis may not have been so robust. Secondly, this systematic review was initially aimed also to include a meta-analysis on MWB consequences in reducing mortality. However, due to differences in the ways included studies presented their results, it was improbable to use many of them in the same meta-analysis. Moreover, in order to do a sizeable meta-analysis, additional data (raw data) was also required from the authors of included papers. Owing to the response from the original authors, I was only able to calculate one additional RR for Koopmans (2010). Therefore, only narrative quantitative analysis was performed. Finally, there were several measures of MWB. This review included studies using a variety of different instruments or scales. The results, therefore, were hard to standardise on the same scale. However, a majority of the included studies, 10/13 (76.92%), focused on the hedonic well-being (positive affect, happiness and life satisfaction) of older people. In addition, as summarised in the methodology and justification chapter (Chapter 3), although different instruments or scales were used, the aspects of MWB they covered were quite similar. Despite the limitations, the results from this review shone a light of the protective effect of MWB in old age. Public policy that focuses on improving MWB could reduce risks in health in old age.

# CHAPTER 6 THE DISTRIBUTION OF MENTAL WELL-BEING IN OLD AGE: 7-YEAR CROSS-SECTIONAL STUDY USING THE HEALTH SURVEY OF ENGLAND (HSE)

## 6.1 INTRODUCTION

This chapter provides an overview of MWB distribution in old age. Previous empirical research has been largely focused on the age-MWB association across the entire lifespan, with opinion varying as to whether this is best represented as ‘U-shaped’, ‘S-shaped’ (visually ‘-shaped’) or a linear pattern. These assumptions drew from different conceptual disciplines including economics, psychology and gerontology (Ulloa et al., 2013).

A ‘U-shaped’ age-well-being association represents a convex association across the lifespan. Economists have strongly supported this relation. Two of the most influential studies were from Blanchflower & Oswald (2004, 2008). They found international evidence of statistically significant ‘U-shaped’ age-well-being (measured by single-item measures of well-being, happiness or life satisfaction) association with its minimum reported around the middle of life. This finding has been replicated and supported by a number of authors (Clark, 2007; Lang et al., 2011; McAdams et al., 2012). Blanchflower & Oswald (2008) used a cross-sectional design drawing upon a number of datasets and using representative snapshots of the population. The ‘U-shaped’ result was based on regression equations with demographic and socio-economic variables controlled while physical health was left uncontrolled. Older people’s MWB gradually increased after middle age once demographic and socio-economic variables were held constant. Besides, the ‘U-shaped’ age-well-being association hold for both men and women and even after controlling for cohort effect by replacing a set of dummy variables for each decade of birth. Nevertheless, in addition to the 10-year age bands, Blanchflower & Oswald (2008) replaced their age variables with a set of dummy variables representing 5-year age bands, from 20 to 85+. Although 3 out of 4 pooled data (US female, Europe male & female samples) explained a strong ‘U-shaped’ pattern, in US male sample the ‘U shape’ turns over again slightly in late life (aged 80+). This finding also demonstrated that there is a possibility that the age-well-being association is not uni-dimensional increase in old age when smaller age bands are used.

An ‘S-shaped’ (visually ‘-shaped’) age-well-being association across lifespan represents a convex association in early and mid-adulthood and a concave association in late adulthood in succession. It shows that rather than a completely ‘U-shape' across the lifespan, an ‘inverted U’ exists at an advanced age. More recent research has documented international evidence of an ‘S-shaped’ age-well-being association (Fischer, 2009; Gwozdz & Sousa-Poza, 2010; Van Landeghem, 2012; Bauer, 2017). Stone et al. (2010) conducted a large size cross-sectional study of 340,847 individuals aged 18-85 years old (using 4-year age bands) in the US. Well-being was measured by positive experiences of happiness and enjoyment and the analyses controlled for socio-demographic covariates. The results show that well-being across the life course generally displayed a U-shape with the minimum reached around the age of 50 years and follow by an ‘inverted U’ shape at advanced age with a second turning point in life around the age of 70 to 75 and decreased afterwards. Van Landeghem (2012) conducted a longitudinal study using 20 years of German Socio-Economic Panel (GSOEP) data with cohort effects controlled. MWB was measured by life satisfaction and age variable was used at 10-year age bands. The results from the regression analysis were consistent with other cross-sectional studies and demonstrated that well-being decreased over the life cycle until the early 50s and increased until the early 70s after which the path became flat and eventually went down again after mid 70s. Both uncontrolled and controlled (i.e. income, marital status, labour force status and disability) models had been tested to confirm the finding.

However, a potential problem with the whole lifecycle age-well-being association adjusted model is that the controlled variables were based on the assumption that the same definitions and standards were used for all age groups (i.e. those aged 20, 50, or 80 above). Investigations into a narrow part of the lifecycle (i.e. old age) can lead to new insights regarding the age-well-being association. Previously, there has been minimal evidence of the distribution of MWB in old age. Empirical evidence generally agreed with an 'inverted U-shape' age-MWB relation for older age groups. Mroczek & Spiro (2005) conducted a 22-year panel study that including approximately 1,927 men aged 40-85 from the Veterans Affairs Normative Ageing Study. Their study provided longitudinal evidence of an inverted 'U-shaped' (concave) age-MWB (measured by life satisfaction) association during late adulthood with a peak around age 65-70 after controlling for personality traits, marital status, and self-rated general health. Tampubolon (2015) also found an inverted 'U-shape' pattern in later life after adjusting for demographic, socio-economic, health and behavioural variables in his recent study using the English Longitudinal Study of Ageing waves 1 to 5. The inverted 'U-shape' age-quality of life (measured by CASP-19) association appeared at the advanced age (aged 50+) with a peak at age 67. Gwozdz & Sousa-Poza (2010) used 13 waves of the German Socio-Economic Panel (GSOEP) and the Survey of Health, Ageing and Retirement in Europe (SHARE) and focused on the age and life satisfaction relation across lifespan with attention on the oldest-old in Germany (aged 75+ defined by Gwozdz & Sousa-Poza, 2010). They observed a 'U-shaped' age and life satisfaction relation for individuals aged 16 to 65 after adjusting for demographic and socio-economic factors with the highest levels of life satisfaction reached at the age of 65 and a rapid decline in life satisfaction for individuals aged 65 and above. The lowest levels of life satisfaction were recorded for the oldest-old (aged 75+). Unlike Mroczek & Spiro (2005) and Tampubolon (2015) who controlled self-rated general health in their regression, Gwozdz & Sousa-Poza (2010) claimed that the rapid decline in life satisfaction in the oldest-old was primarily attributed to low levels of self-assessed general health.

According to Erik Erikson (1982)'s stages of human development, late adulthood begins in one's sixties. However, older people were often lumped together, grouping everyone over the age of 60 and ignoring the fact that a 60-year-old's experience of life is much different from an 80-year-old's. Previous research has recognised the diversity of old age. However, there is little consensus on the nature or number of chronological sub-groups. Researchers in ageing may prefer to use combination terms for older age groups: young-old (usually defined as 60 or 65 to 70 or 75 years), old-old (70 or 75 to 80 or 85 years), and oldest-old (85+) (Garfein & Herzog, 1995; von Humboldt & Leal, 2014). Most of the previous research on MWB distribution used 5-year age bands or even 10-year age bands. However, the oldest-old might be more diverse compared to the younger old when using smaller age bands (3-year age bands or even 1-year age bands).

Nonetheless, most of the previous studies only provided evidence on an age - hedonic well-being association, little is known about the age - eudaimonic well-being association or age – MWB association. Despite the influential factors controlled in the multivariate regression analysis on the age-MWB association, this chapter intends to provide evidence regarding the distribution of MWB in old age in an unadjusted model using 7 waves of Health Survey England (HSE) combined datasets. With the intention of detecting the variations in MWB distribution in old age, the descriptive analysis also compared different age bands: 5-year, 3-year and 1-year. The research question undertaken in this chapter is how does observed MWB vary over the old age? This chapter will also guide further quantitative analyses on the determinants of MWB in chapter 7 to detect whether chronological age is the best predictor of older people's MWB? Simply speaking, whether chronological age independently predicts older people's MWB. Moreover, if there are variations in the MWB distribution, what caused these differences?

## 6.2 AIM AND HYPOTHESIS

This chapter intends to describe the distribution of MWB and examine the age-MWB association in old age. By doing this, I hope to identify the variations in MWB distribution and generate testable hypotheses on the potential determinants of MWB in old age. The hypothesis undertaken in this chapter is the association between MWB and old age (aged 60+) is not a uni-dimensional increase. 'inverted U-shaped' pattern with MWB decreases at advanced age groups is anticipated to appear. Besides, variations in distribution within older age groups are expected to appear.

## 6.3 METHODS

### 6.3.1 SAMPLE

The Health Survey for England (HSE) 2010-2016 (7 year) datasets are publicly available secondary datasets. All datasets were downloaded from the UK data service under project ID 168037. The UK data service series code for each dataset was: HSE2010 (No. 6986), HSE2011 (No. 7260), HSE2012 (No. 7480), HSE2013 (No. 7649), HSE2014 (No. 7919), HSE2015 (No. 8280) and HSE2016 (No. 8334). Statistical analysis was carried out using Stata 15. V2.

### 6.3.2 MEASURES

*Age*

The age variables used in the HSE 2010-2016 7-years' datasets were not the same (see Table 12 below). Only one variable 'age16g10' (respondents aged 16-75+ in 10-year age bands) was repeated every year. However, as the main focus group in this PhD is older people, 'age16g10' which only generated three old-age groups (55-64, 65-74, and 75+) might not be able to catch a whole picture of MWB distribution in old age. Nevertheless, the respondents' chronological (one-year) ages were only reported in the first 5-years' datasets: HSE 2010-2014 (labelled as: 'age', 'Age' and 'Age90' respectively). In HSE 2015 & 2016 datasets, adult respondents' age was grouped under variables 'Age16g5' (age 16+ in 5-year bands) and 'Age35' (age groups in approximately 3-year bands for age 0-15 and 5-year bands for age 16+).

*Table 12.Original age variables in HSE 2010-2016*

| Year | Age<br>(Age, in one-year bands) | age16g10<br>(Age 16-75+, in ten-year bands) | Age16g5<br>(Age 16+, five-year bands) | Age35<br>(Respondent age - grouped, three-year bands for 0-15, five-year bands 16+) |
|---|---|---|---|---|
| 2010 | √ | √ | | |
| 2011 | √ | √ | | |
| 2012 | √ | √ | | |
| 2013 | √ | √ | | |
| 2014 | √ | √ | | |
| 2015 | | √ | √ | √ |
| 2016 | | √ | √ | √ |

To standardise the age variables for all 7-years' datasets, I firstly generated and labelled the variable, 'Age16g5', as "Age 16+, 5-year bands" for datasets HSE 2010, 2011, 2012, 2013 and 2014. However, as reviewed, MWB distribution in 5-year bands has been heavily studied in previous research. Subtle but important variations with (older) age groups might not be evident when this is pooled in 5-year bands. Therefore, another variable 'Ageold' (as "Age 60+, approximately 3-year bands") was also generated for datasets HSE 2010-2014. In summary, age is analysed in three ways – one-year bands, three-year bands and five-year bands.

*Mental well-being*

There were many different definitions of MWB. This thesis did not engage in debates about MWB and defined it as comprising both positive functioning (eudaimonic well-being) and positive feelings (hedonic well-being) (Stewart-Brown, 2015, 2018). The HSE2010-2016 7-year surveys included questions on MWB in paper self-completion questionnaires, which were administered to adults aged 16+ during the face to face interview. Data on MWB was collected using the Warwick-Edinburgh Mental Well-being 14-item Scale (WEMWBS), which was firstly introduced in HSE2010 and has been used annually ever since. The WEMWBS was developed from both a hedonic and eudaimonic perspective as an instrument to capture a broad concept of MWB that includes psychological functioning, cognitive-evaluative dimensions and affective-emotional aspects (Stewart-Brown, 2017; ONS, 2012). The WEMWBS scores were stored in numerical type for each of the HSE 7-years' dataset on a scale of 14-70. The scores were based on individuals' responses for 14 positive statements (score 14 for those who answer 'rarely' to all questions while score 70 for those who answer 'all of the time' to all questions). The higher the score, the greater the individual's MWB.

### 6.3.3 DESIGN

*<u>'Merge'- 1:1 for individual & household data in HSE2010-2014</u>*

'Merge' command in Stata combines datasets 'horizontally' and adds new variables to the existing observations (Baum, 2016). Each of the HSE2010-2014 datasets consists of individual and household survey data in two separate files. The individual dataset contains data for all individuals in a household who gave a full interview and includes information from the household questionnaire, main individual schedule, self-completions and the nurse visit (where one occurred). The household dataset contains data on household composition, sex, age and marital status for all individuals in co-operating households (include those who were not interviewed). In this case, the household datasets had more observations (not-interviewed) than the individual datasets. To combine an annual completed (individual and household) dataset required specifying a one-to-one match merge by personal serial number from the individual and household datasets (see Figure 32 below).


*Figure 32. 1:1 Merge for HSE 2010-2014*

The merge process firstly tried to keep all of the observations from household survey datasets. However, this would also create a large number of missing variables in the household-only observations. Moreover, as the MWB questionnaire was only included in individual surveys, household-only observations might not provide any MWB data in this case. Hence, a 'keep (match)' method was used, which kept only observations in both surveys. This method dropped a total number of 15,021 household-only observations from HSE2010-2014.

*'Append'-combining HSE2010-2016 datasets*

Since the HSE surveys are cross-sectional surveys, an 'append' method was used to combine each of the seven years. 'Append' command in Stata combines datasets 'vertically' and adds new observations to the existing dataset. The aim of combining multiple years' datasets was to create a large enough older population sample to be able to draw a whole picture of MWB distribution. However, the main focus/topics of each of the 7-years HSE surveys were quite different. There was a risk to appending entire datasets since new variables were added to different surveys. 'Append' to all would generate missing variables to previous years' observations. These missing variables cannot be treated the same as those did not respond to the survey questions. Hence, an 'append (keep)' method was undertaken to keep only specified variables.

After appending datasets, HSE2010-2016 7-year combined dataset included a total number of 79,937 observations, and HSE 2010-2014 5-year combined dataset included a total number of 56,122 observations (see Table 13 below).

*Table 13.No. of observations in HSE*

| | Sex | Under 16 | 16+ | 60+ | Total sample |
|---|---|---|---|---|---|
| **HSE 2010-2016** | Male | 11,020 | 25,847 | 9,059 | 36,867 |
| | Female | 10,680 | 32,390 | 10,635 | 43,070 |
| | Total | 21,700 | 58,237 | 19,694 | 79,937 |
| **HSE 2010-2014** | Male | 7,136 | 18,717 | 6,416 | 36,867 |
| | Female | 6,794 | 23,475 | 7,648 | 43,070 |
| | Total | 13,930 | 42,192 | 14,064 | 56,122 |

### 6.3.4 ANALYSIS

In order to describe MWB distribution in old age, the analysis carried out in this chapter did not control any variable that influences MWB. The reason for doing this was controlling other independent variables is based on the assumption that age is independently and significantly associated with MWB. However, we cannot yet identify whether MWB distribution is arguably age-driven or more inter-personal. Instead of drawing our assumptions so early, descriptive analysis was preferred. The descriptive analysis included an analysis of MWB distribution on approximately 5-year bands using the HSE 2010-2016 7-year combined dataset and a 'drill-down' analysis of MWB distribution in old age comparing approximately 5-year, 3-year and 1-year age bands using the HSE2010-2014 5-year combined dataset.

## 6.4 RESULTS

### 6.4.1 MWB DISTRIBUTION ACROSS LIFE

*'HSE2010-2016 7-year combined dataset'*

The HSE2010-2016 7-year combined dataset included a total number of 79,937 observations, with 21,700 observations under age 16 that did not apply to the MWB questions as well. The total observations for WEMWBS was 48,396, with a missing number of 9,841 participants did not response to WEMWBS questions (see Table 14 below).

*Table 14.Observations in HSE2010-2016*

| Observations | Under 16 | Missing | Total sample |
|---|---|---|---|
| **Age** | 21,700 | - | 58,237 |
| **WEMWBS** | 21,700 | 9,841 | 48,396 |

Population WEMWBS was left-skewed with a mean of 51.20 (see Figure 33 below, mean WEMWBS is presented as the reference line). A Shapiro-Wilk W test also confirmed that population WEMWBS was not normally distributed. However, as the sample size was considerably large, a two-sample t-test was still carried out to test that individuals' WEMWBS significantly differed from group WEMWBS means.

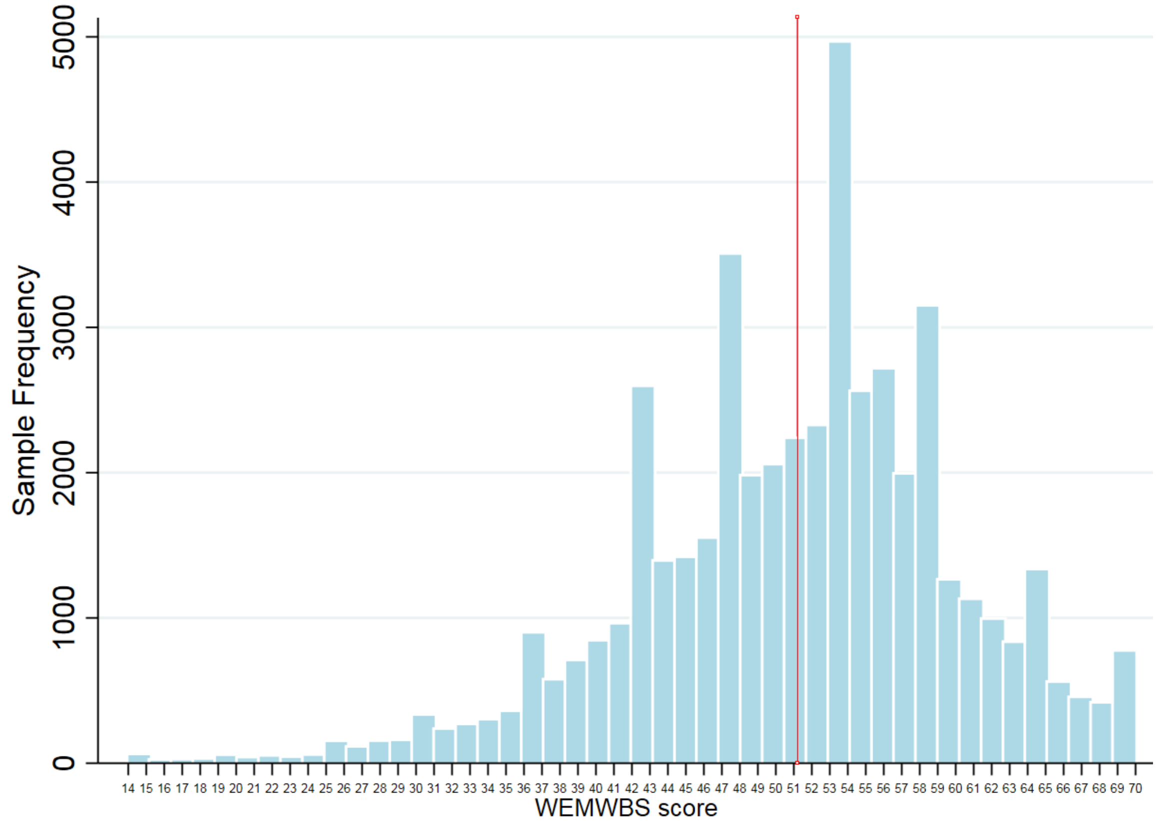



*Figure 33. WEMWBS score distribution HSE2010-16*

When looking at the mean WEMWBS scores of the different age groups in the 5-year age bands, the sample population (age 16+ in England) scored 51.20 (95%CI 51.20–51.21) on average, ranged from 48.84 (95%CI 47.84–49.83) to 53.09 (95%CI 52.82–53.37) (see Table 15 below). The highest mean score of 53.09 was found in the 65-69 age group, while the lowest score of 48.84 was found in the 90+ age group.

*Table 15.Mean WEMWBS (95%CI) among different age groups from HSE2010-2016*

| Age | No. observations | Mean WEMWBS | Confidence Interval (95%) |
|---|---|---|---|
| **16-17** | 1,390 | 50.83 | (50.34–51.33) |
| **18-19** | 1,205 | 50.94 | (50.39–51.50) |
| **20-24** | 3,047 | 50.75 | (50.41–51.09) |
| **25-29** | 3,893 | 51.19 | (50.90–51.49) |
| **30-34** | 4,530 | 51.37 | (51.10–51.64) |
| **35-39** | 4,720 | 51.07 | (50.80–51.34) |
| **40-44** | 5,049 | 50.81 | (50.54–51.08) |
| **45-49** | 5,273 | 50.30 | (50.03–50.57) |
| **50-54** | 5,035 | 50.31 | (50.04–50.59) |
| **55-59** | 4,401 | 50.61 | (50.32–50.90) |
| **60-64** | 4,812 | 51.85 | (51.57–52.13) |
| **65-69** | 4,663 | 53.09 | (52.82–53.37) |
| **70-74** | 3,634 | 52.19 | (51.86–52.52) |
| **75-79** | 2,881 | 51.85 | (51.48–52.22) |
| **80-84** | 2,102 | 50.72 | (50.24–51.20) |
| **85-89** | 1,154 | 49.42 | (48.78–50.06) |
| **90+** | 448 | 48.84 | (47.84–49.83) |
| ***Total*** | ***58,237*** | ***51.20*** | ***(51.20–51.21)*** |

MWB distribution did not show much difference among young adults in their late teens (late adolescence), twenties and thirties (early adulthood). However, starting from the early forties (middle adulthood), MWB presented a decrease in distribution and reached its first turning point around the late forties and early fifties. During late adulthood (60+ according to Erik Erikson's stages of human development), MWB distribution presented an inverted 'U-shape', with the highest mean MWB score across lifetime reached around the late sixties (second turning point). Although WEMWBS scores were found to be relatively low among people in middle adulthood (age 45-54), an even steeper decline was found in those aged 70 above (see Figure 34 below). The variations in WEMWBS scores were more evident among the older-old (80-89) and the oldest-old (90+) age groups in comparison with all other age groups. Drawing upon the HSE2010-2016 7-year combined dataset, MWB was slight ‘S-shaped' across the lifespan in 5-year age bands for the population aged 16+ in England. Population mean WEMWBS is presented as a reference line Figure 34.

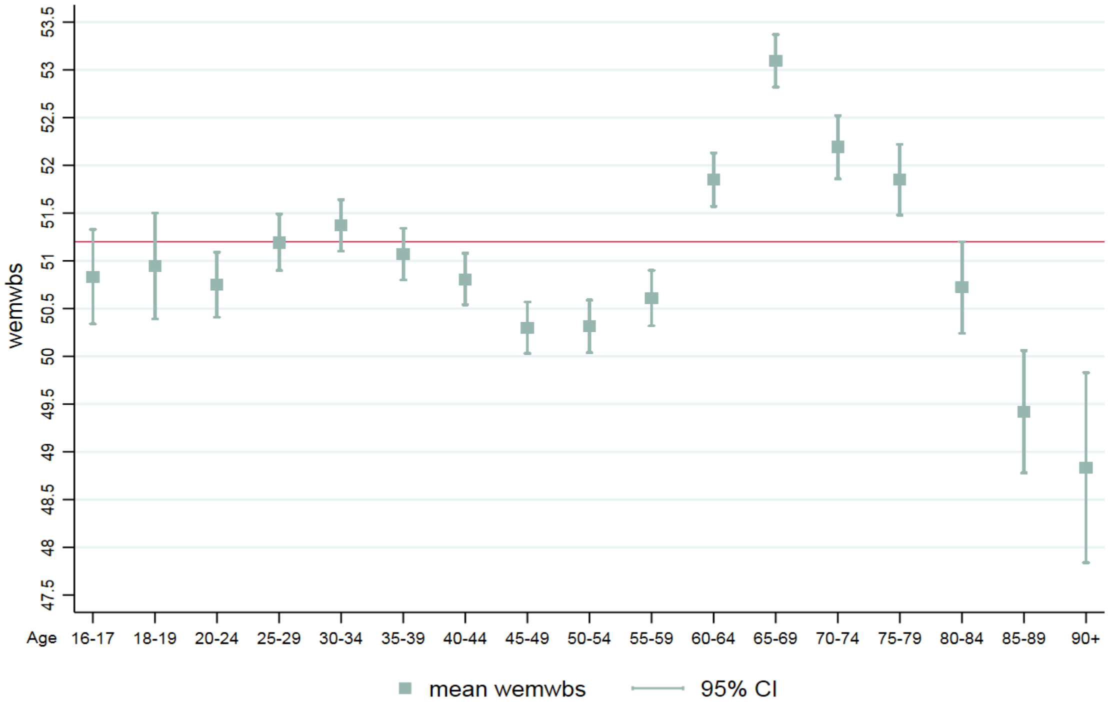



*Figure 34. Mean WEMWBS 95%CI among different age groups from HSE2010-2016*

Box-and-whisker plots were undertaken to show the MWB variations within each age group, with the group median presented within the boxes and group mean presented as the dashed line outside the boxes. The highest WEMWBS score is presented as the reference line (see Figure 35 below). Also, MWB distribution did not show much difference when comparing men with women. A slightly ‘S-shaped' MWB distribution across the lifetime in 5-year age bands was found out both in men and women (see Figure 36 below).

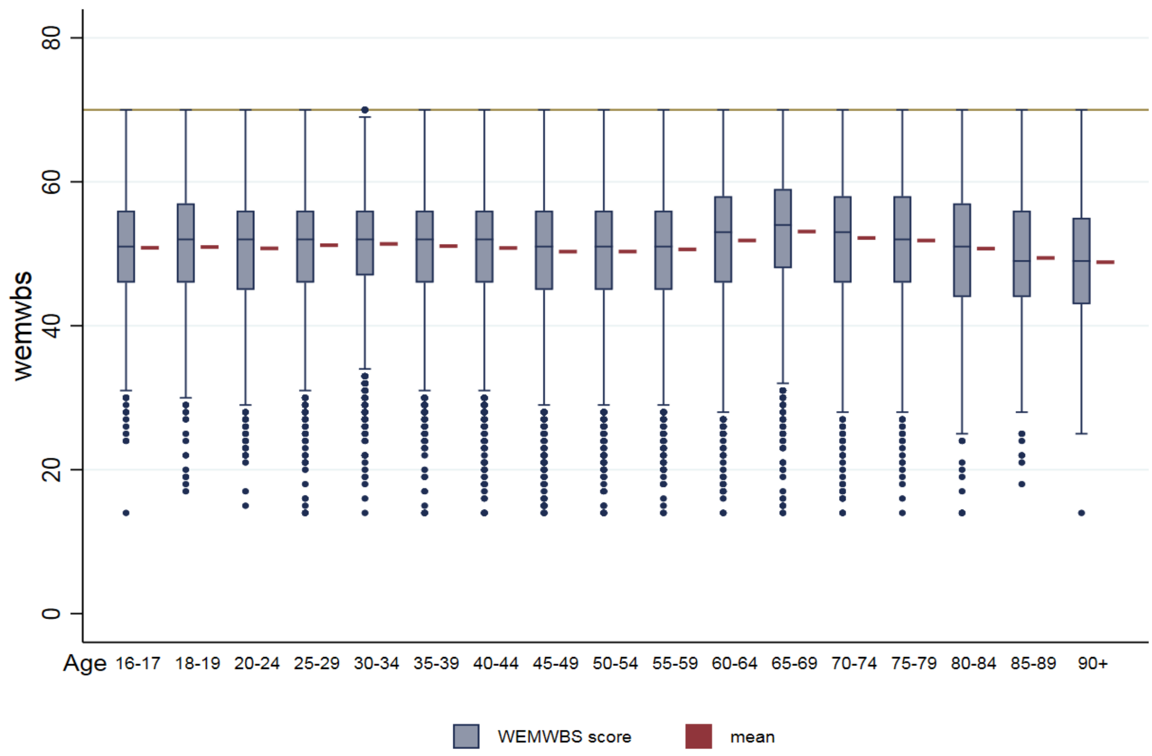



*Figure 35. WEMWBS distribution & mean in HSE2010-2016*

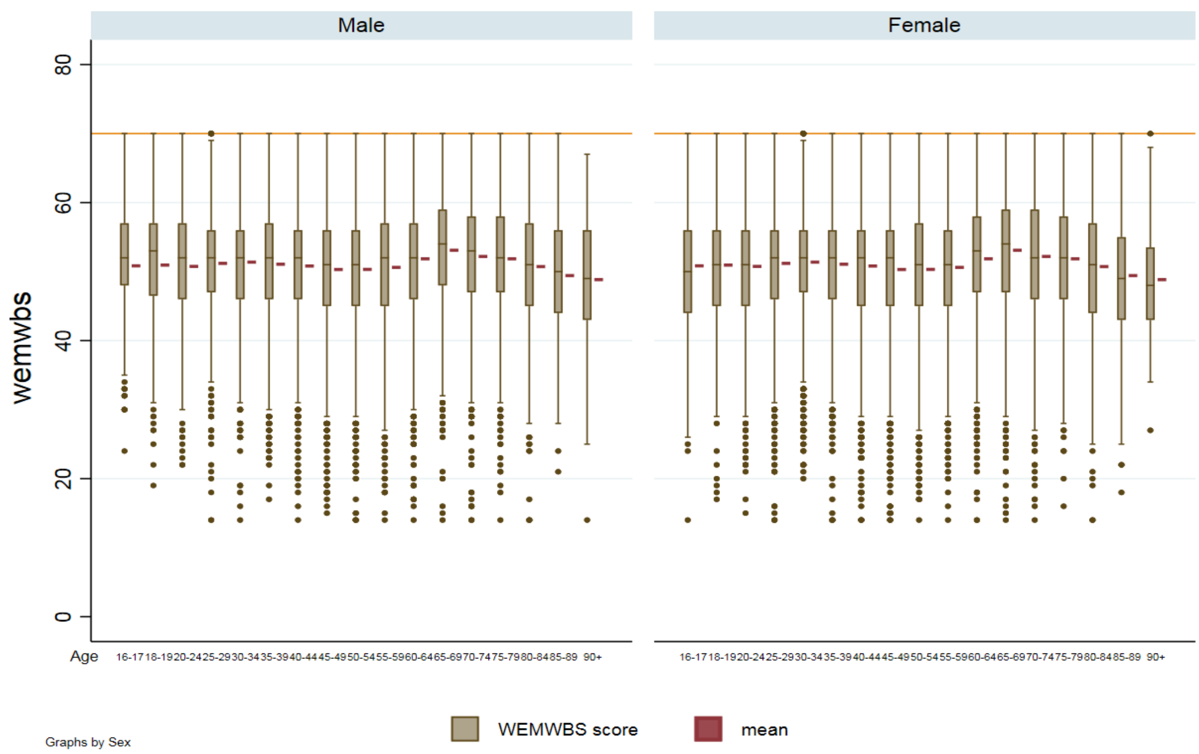



*Figure 36. WEMWBS among different age groups, by Sex, HSE2010-2016*

### 6.4.2 MWB DISTRIBUTION IN OLD AGE – 5-year bands vs 3-year bands using the HSE2010-2014 dataset

*'HSE2010-2014 5-year combined dataset'*

*Table 16.Observations in HSE2010-2014*

| **Observations** | **Under 16** | **Missing** | **Total sample** |
|---|---|---|---|
| **Age** | 13,930 | - | 42,192 |
| **WEMWBS** | 13,930 | 8,599 | 33,593 |

The HSE2010-2014 5-year combined dataset included a total number of 56,122 observations, with 13,930 observations under age 16 (for whom the MWB questions do not apply). The total observations for WEMWBS was 33,593, a missing number of 8,599 participants did not response to WEMWBS questions (see Table 16 above).

A 'drill-down' analysis of MWB distribution in old age was undertaken to compare approximately 5-year, 3-year and 1-year age bands using the HSE2010-2014 5-year combined dataset. The total sample of older people aged 60+ was 14,064. Breaking down the sample description in 5-year and 3-year age bands presented a trend of decreasing in sample size and increasing missing in WEMWBS in advanced age (see Table 17 below).

*Table 17.No. of observations in 5-year and 3-year age bands*

| 5-year bands | wemwbs | Missing (%) | Total Sample | 3-year bands | wemwbs | Missing (%) | Total Sample |
|---|---|---|---|---|---|---|---|
| **60-64** | 2,858 | 617 (17.8%) | 3,475 | **60-62** | 1,662 | 364 (18.0%) | 2,026 |
| **65-69** | 2,676 | 582 (17.9%) | 3,258 | **63-65** | 1,785 | 381 (17.6%) | 2,166 |
| **70-74** | 2,054 | 580 (22.0%) | 2,634 | **66-68** | 1,647 | 354 (17.7%) | 2,001 |
| **75-79** | 1,513 | 511 (25.2%) | 2,024 | **69-71** | 1,330 | 314 (19.1%) | 1,644 |
| **80-84** | 1,036 | 496 (32.4%) | 1,532 | **72-74** | 1,164 | 366 (23.9%) | 1,530 |
| **85-89** | 521 | 310 (37.3%) | 831 | **75-77** | 979 | 306 (23.8%) | 1,285 |
| **90+** | 180 | 130 (41.9%) | 310 | **78-80** | 780 | 320 (29.1%) | 1,100 |
| | | | | **81-83** | 623 | 286 (31.5%) | 909 |
| | | | | **84-86** | 437 | 252 (36.6%) | 689 |
| | | | | **87-89** | 251 | 153 (37.9%) | 404 |
| | | | | **90-94** | 166 | 113 (40.5%) | 279 |
| | | | | **95+** | 14 | 17 (54.8%) | 31 |
| **Total** | 10,838 | 3,226 | 14,064 | **Total** | 10,838 | 3,226 | 14,064 |

Older people (age 60+ in England)'s WEMWBS was slightly left-skewed with the sample population mean scored at 52.08 (95%CI 51.91–52.25) (presented as a reference line in Figure 37 below). A Shapiro-Wilk W test was again carried out to confirm that older people's WEMWBS were not normally distributed, and a two-sample t-test was carried out to test that individuals' WEMWBS significantly differed from group WEMWBS means.

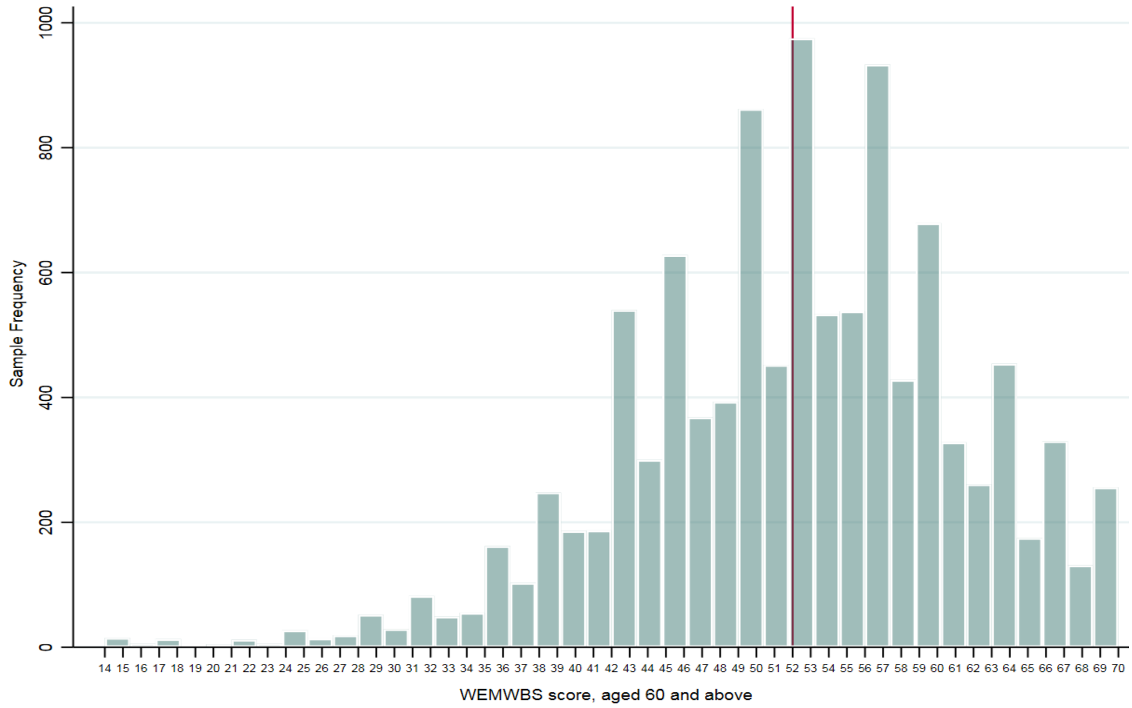



*Figure 37. WEMWBS score distribution, sample aged 60+, HSE2010-2014*

During late adulthood (60+), MWB distribution in 5-year age bands presented a left-skewed and slightly inverted ‘U-shape', with the highest level of MWB reached around the late sixties (age 65-69) and the lowest level reached at the 5-year bands’ oldest-old group (age 90+). This distribution did not show much difference between men and women (see Figure 38 below). However, when grouping older people into closer age bands, a slightly ‘S-shaped’ MWB distribution in 3-year bands was found. Although the highest level of MWB still appeared in the late sixties (age 66-68), individuals' MWB dramatically increased at the oldest-old group (age 95+) again after reaching their lowest level in the late eighties (age 87-89) and early nineties (age 90-94) (also see Figure 38 below).

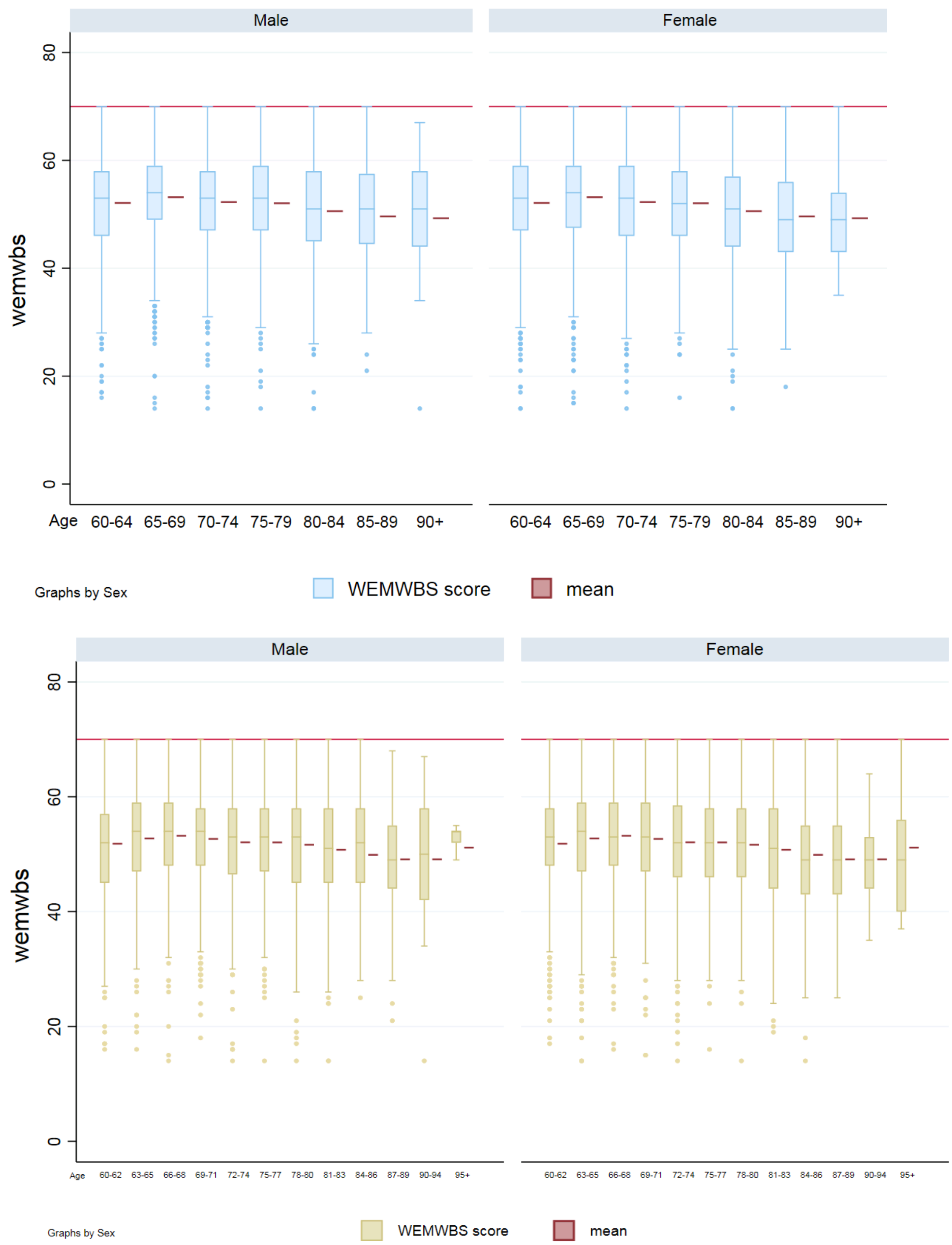



*Figure 38.WEMWBS in old age, by Sex, 5-year bands (top) vs 3-year bands (bottom)*

Unlike the distribution in the 5-year bands, men and women conducted very different MWB distribution in the 3-year bands' oldest-old group (age 95+). Oldest men reported less varied WEMWBS score ranged from 49 to 55, with a median of 54 being higher than the group mean of 51.14. Oldest women, on the other hand, reported a much more varied WEMWBS score ranged from 37 to 70, with a median of 49 being lower than the group mean (see Table 18 below).

*Table 18.WEMWBS distribution in the oldest-old group (age 95+)*

| | Men | Women |
|---|---|---|
| **(Response to MWB questions / Total sample)** | **(5/10)** | **(9/21)** |
| **Mean wemwbs in age 95+ group** | **52.80** | **50.22** |
| **wemwbs score** | 49 | 37 |
| | 52 | 40 |
| | 54 | 40 |
| | 54 | 43 |
| | 55 | 49 |
| | | 54 |
| | | 56 |
| | | 63 |
| | | 70 |

When considering the mean WEMWBS scores of different age groups, the sample population (age 60+ in England) scored 52.08 (95%CI 51.91–52.25) on average, ranged from 49.27 (95%CI 48.06–50.47) to 53.17 (95%CI 52.84–53.51) in 5-year age bands, and 49.10 (95%CI 48.01–50.19) to 53.21 (95%CI 52.79–53.63) in 3-year age bands (see Table 19 below). The mean WEMWBS scores were found to be similar among the same age groups in 5-year and 3-year bands with the only exception appearing in the oldest-old age group (age 95+).

*Table 19.Mean WEMWBS, 95%CI, in 5-year & 3-year bands*

| 5-year bands | No. obs | Mean WEMWBS | Confidence Interval (95%) | 3-year bands | No. obs | Mean WEMWBS | Confidence Interval (95%) |
|---|---|---|---|---|---|---|---|
| **60-64** | 3,475 | 52.10 | (51.77–52.44) | **60-62** | 2,026 | 51.83 | (51.38–52.27) |
| **65-69** | 3,258 | 53.17 | (52.84–53.51) | **63-65** | 2,166 | 52.75 | (52.33–53.17) |
| **70-74** | 2,634 | 52.28 | (51.88–52.67) | **66-68** | 2,001 | 53.21 | (52.79–53.63) |
| **75-79** | 2,024 | 52.05 | (51.59–52.50) | **69-71** | 1,644 | 52.67 | (52.19–53.14) |
| **80-84** | 1,532 | 50.58 | (49.98–51.18) | **72-74** | 1,530 | 52.07 | (51.53–52.61) |
| **85-89** | 831 | 49.61 | (48.83–50.39) | **75-77** | 1,285 | 52.05 | (51.50–52.60) |
| **90+** | 310 | 49.27 | (48.06–50.47) | **78-80** | 1,100 | 51.64 | (50.98–52.31) |
| | | | | **81-83** | 909 | 50.77 | (49.97–51.57) |
| | | | | **84-86** | 689 | 49.89 | (49.03–50.74) |
| | | | | **87-89** | 404 | 49.10 | (48.01–50.19) |
| | | | | **90-94** | 279 | 49.11 | (47.86–50.35) |
| | | | | **95+** | 31 | 51.14 | (45.87–56.41) |
| ***Total*** | ***14,064*** | ***52.08*** | ***(51.91–52.25)*** | ***Total*** | ***14,064*** | ***52.08*** | ***(51.91–52.25)*** |

Nevertheless, the WEMWBS scores for people in the 60s are significantly higher than for those over 80. The variation of mean WEMWBS scores was much more evident in the oldest-old (95+) age groups in the 3-year bands in comparison with all other age groups (see Figure 39 below). Those aged 90-94 in the 3-year bands presented similar mean and confidence interval as those aged 90+ in the 5-year bands. The biggest increase and variation in mean WEMWBS scores is among those aged 94+. Also presented in Table 18 above, the WEMWBS distribution in the oldest-old group (aged 95+), however, demonstrate a possibility of happy survivors' effect as the WEMWBS ranged from 37 to 70.

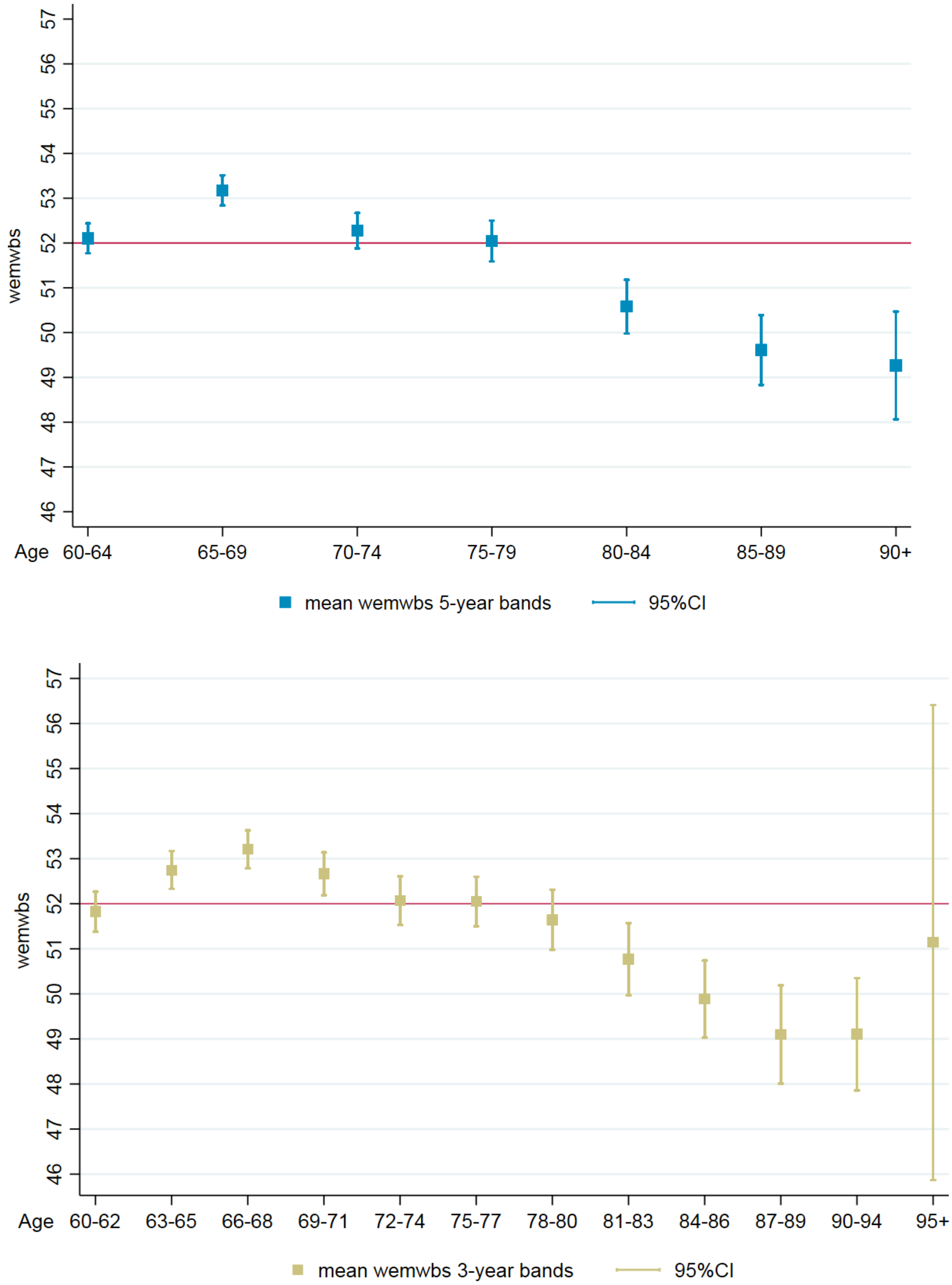



*Figure 39. Mean WEMWBS, 95%CI, among different age groups, 5-year bands (top) vs 3-year bands (bottom)*

### 6.4.3 MWB DISTRIBUTION IN OLD AGE - 1-year bands using the HSE2010-2014 dataset

When further ‘drill-down’ the analysis to 1-year age bands, the slightly ‘S-shaped’ MWB distribution in old age is also confirmed (see Figure 40 below). The variations in MWB distribution between the sixties and seventies became much smaller in 1-year age bands compared to those in 5-year and 3-year bands. Older people’s MWB displayed a slightly inverted ‘U-shape’ before the eighties with the highest level of MWB reached at age 66 and age 68. From age 80 above, MWB displayed a deeper ‘U-shape’ to reach its lowest level at age 93 and increased again after that. The mean WEMWBS scores at each age year ranged from 46.41 (95%CI 41.76–51.07) at age 93 to 54.67 (95%CI 17.38–91.96) at age 98. The variation of mean WEMWBS scores was huge in the oldest-old age groups (see Figure 41 below). Variations in MWB distribution between men and women were also confirmed for older people aged 92+. This result might also be due to the reduced sample of older people aged 92+ in total (76), of whom 37 responded to the MWB questionnaire (10 men and 27 women).

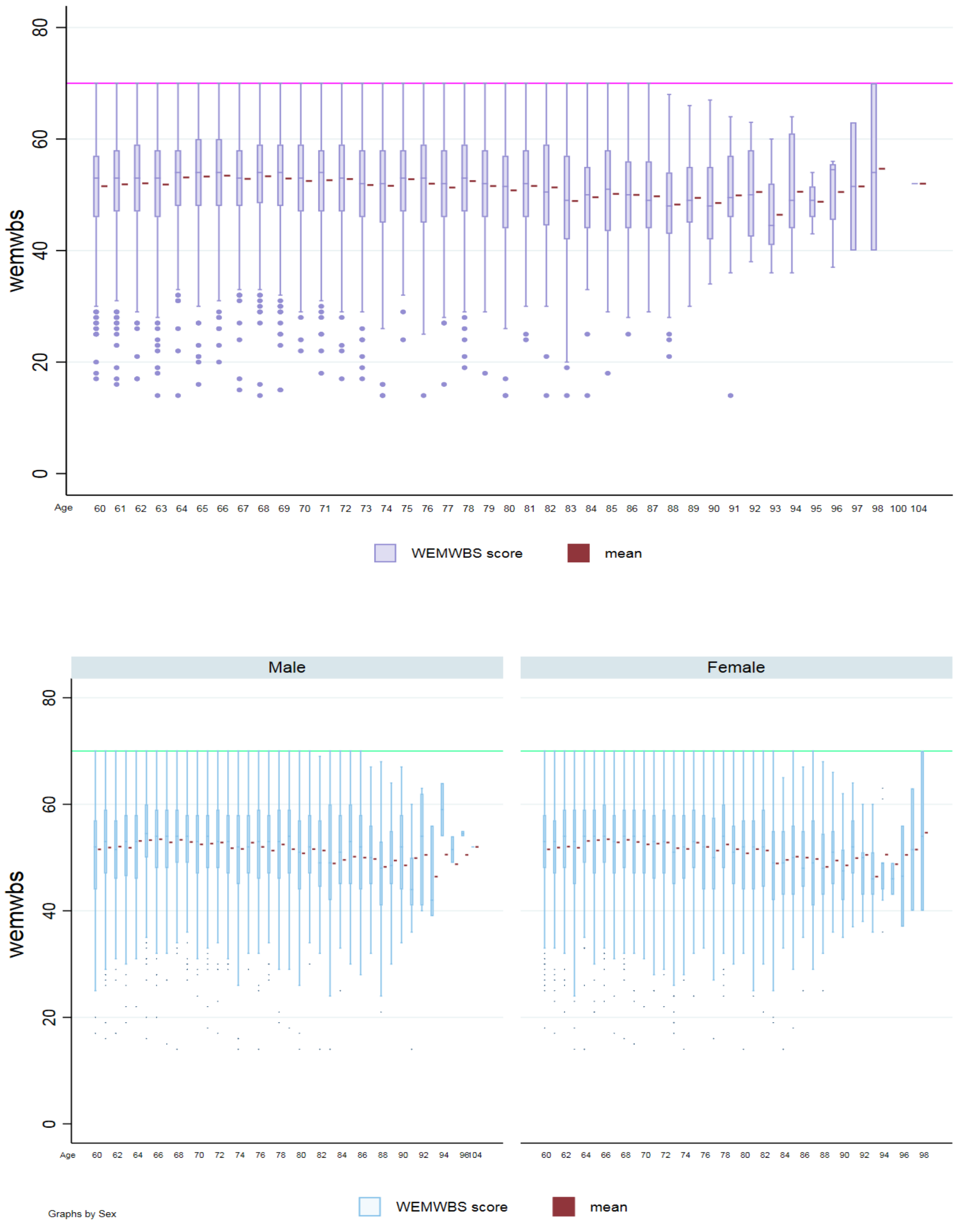



*Figure 40. MWB distribution in old age, by Sex, 1-year band*

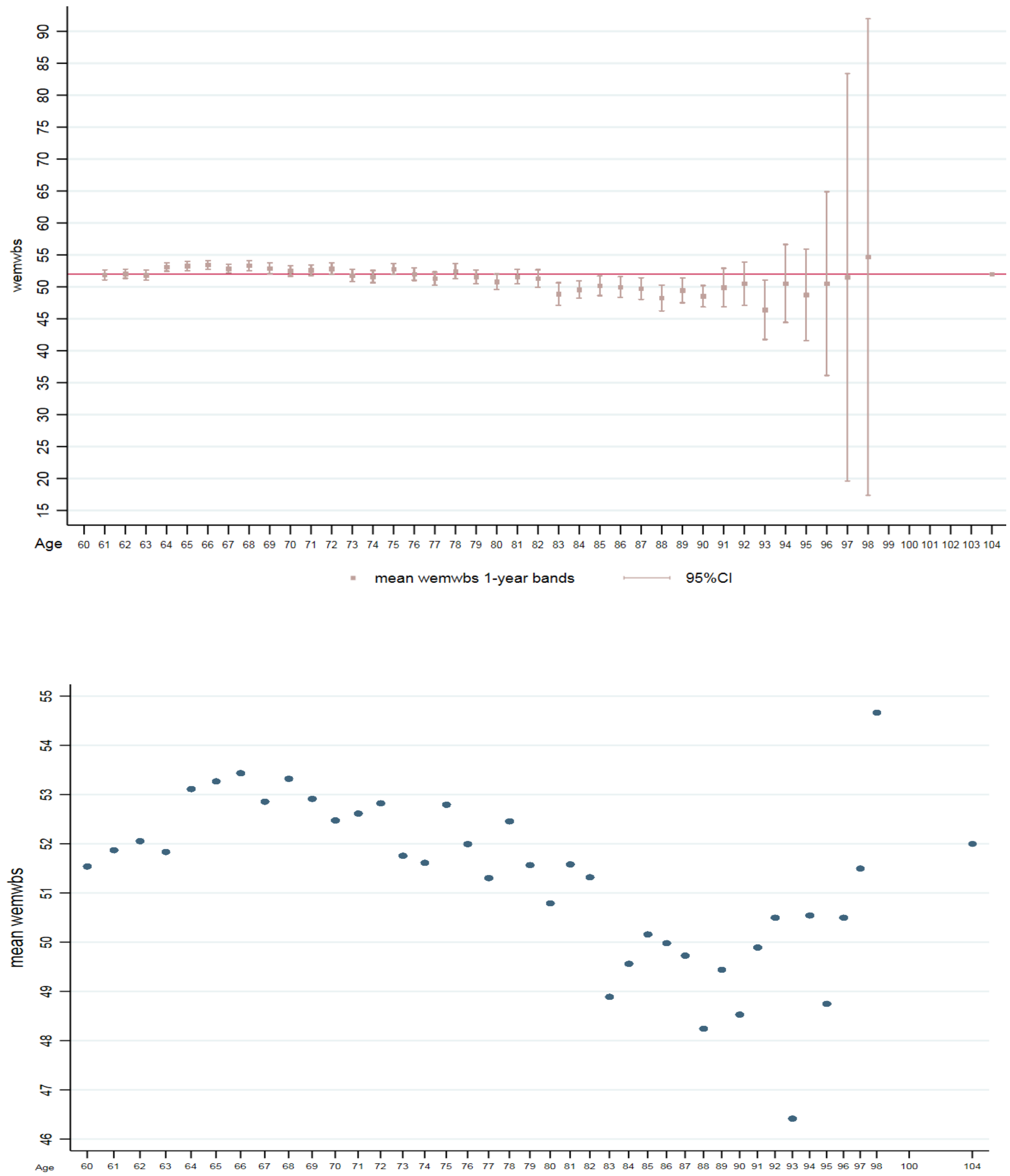



*Figure 41. Mean WEMWBS, 95%CI, 1-year band*

To summarise the results, a combined MWB distribution joint-line graph by mean WEMWBS scores in 1-year, proxy. 3-year and approximately 5-year age bands was performed (see Figure 42 below). Generally speaking, MWB distribution was slightly 'S-shaped' in older people aged 60+ in England. Comparing the 1-year, 3-year and 5-year age bands, there was a much smaller variation in MWB distribution among the younger-old group (aged 60-75) than the older-old group (aged 76-90). However, there was a great variety in MWB among the oldest-old group (aged 90+). This finding on the variation pattern also held for men and women (see Figure 43 below). Although the results might be due to the reduced sample size in the oldest-old group, it still suggests a research interest on the determinants of MWB in old age.

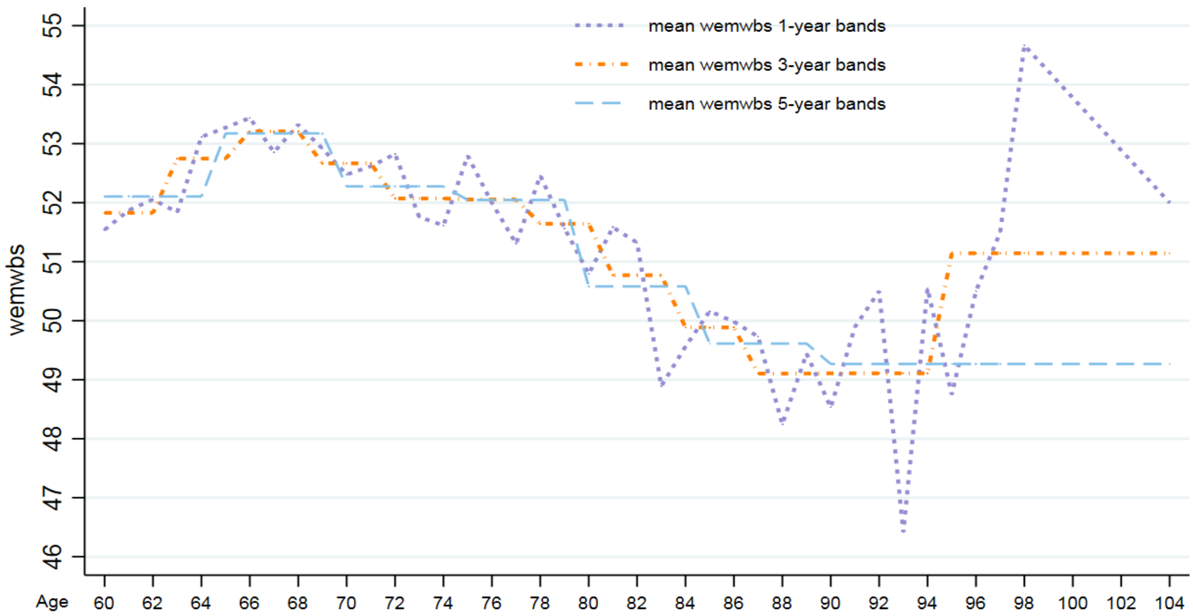



*Figure 42. Combined mean WEMWBS in old age, 1-, 3-, 5-year bands*

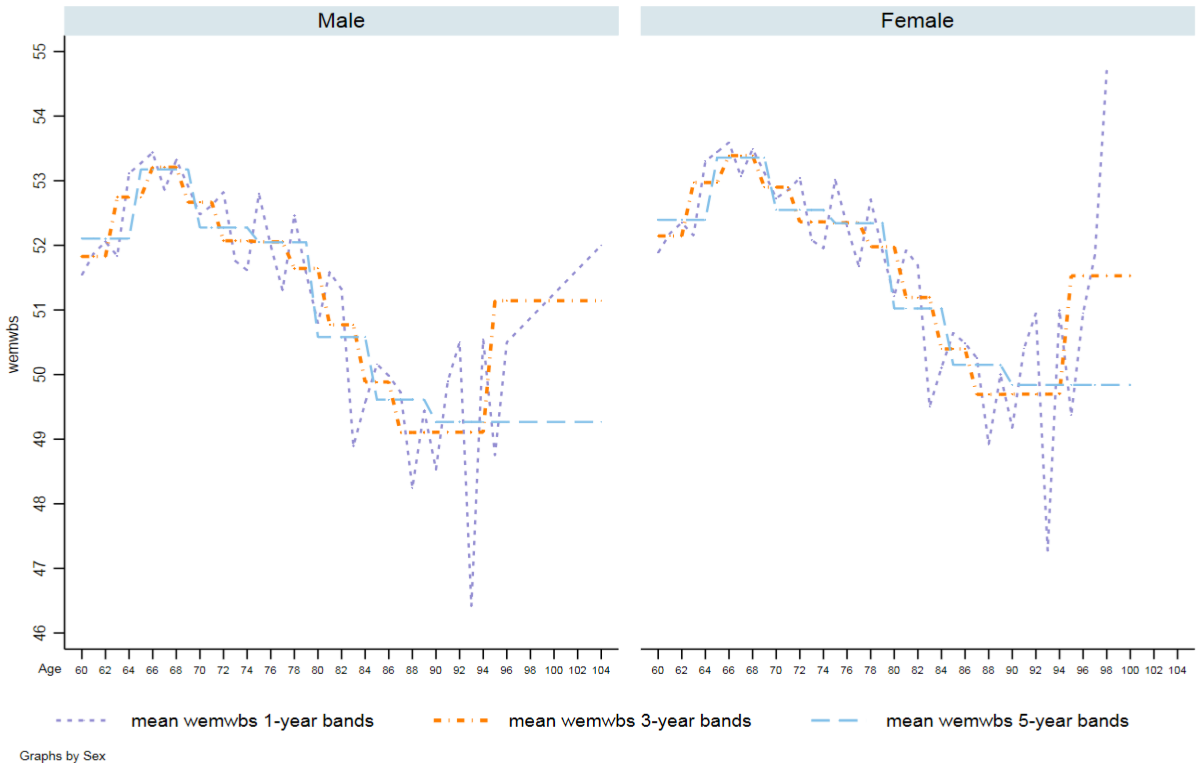



*Figure 43. Combined mean WEMWBS in old age, by Sex, 1-, 3-, 5-year bands*

## 6.4 DISCUSSION

This chapter analysed MWB for 58,237 adults in England, collected over seven years between 2010 and 2016. The main findings were:

1. Across the lifetime, in 5-year age bands, the highest average levels of MWB were reported by those aged 65 to 69, while the lowest levels were reported by those aged 90+. The overall MWB distribution was 'S-shaped' with the first low level of MWB, on average, reported by those aged 45 to 54. MWB scores also fell amongst the older-old age groups (those aged 70 and over) – this fall was steeper compared with the first fall at middle age (35-49). Individuals aged 60-79 at 95%CI reported higher than the population mean MWB.
2. Older (60+) people's MWB displayed a slightly inverted 'U-shape' before the eighties with the highest average levels of MWB reported by those aged 66-68 in

3-year age bands. A more in-depth ‘U-shape’ displayed afterwards with the lowest reported by those aged 87-89 and aged 90-94. MWB scores was found out to increase again at the oldest-old group (age 95+). Oldest (95+) men reported less varied WEMWBS than oldest women. Individuals aged 63-71 at 95%CI reported higher than the sample mean MWB.

3. Older people’s MWB displayed a slightly inverted ‘U-shape’ before the eighties with the highest level of MWB reached at age 66 and age 68 in 1-year age bands. From age 80 above, MWB displayed a deeper ‘U-shape’ and reached its lowest level at age 93 and increased again afterwards. The oldest-old are more diverse than younger-old. In 1-year bands, those aged 93 reported the lowest average level of MWB of 46.41 (95%CI 41.76–51.07) and those aged 98 reported the highest average level of MWB of 54.67 (95%CI 17.38–91.96).

The findings agreed with recent studies indicating inverted ‘U-shape’ MWB distribution in the 60-90 age group, with the highest level of MWB reached at the late sixties (Mroczek & Spiro, 2005; Tampubolon, 2015; Gwozdz & Sousa-Poza, 2010). However, the findings differed from those previous studies, as this study included smaller age bands, and found that MWB increased in the oldest-old. Moreover, in this first ‘drill-down’ analysis of older people’s MWB using different age bands, the oldest-old are more diverse than younger-old. This finding adds to the initial argument in psychological theories of ageing that ageing is not a one-dimensional process of decline but includes the possibility of gains as well (Schaie & Will, 2000).

Despite this, however, there is a limitation with smaller age bands analysis. As summarised from Chapter 5, MWB is also a determinant of physical health and predicts mortality rates. The older the age band, the more people there will have been lost from that cohort and these will be disproportionately people with lower MWB/more mental illness. Smaller age bands analysis might be, in this case, biased by this healthy survivor effect.

In addition, the description of variation of MWB with (older) age in this chapter did not control for physical health and socio-demographic factors. Gwozdz & Sousa-Poza (2010) documented that there seems to be a pure age effect that causes life satisfaction to decrease steeply among the oldest old (85+). However, whether the difference in MWB distribution across the entire older age is arguably age-driven or more inter-personal remains a future research interest. Cross-sectional regression analyses will be presented in the next chapter in order to underpin the complex relationship between older age and MWB.

The descriptive analysis of the distribution of MWB in old age left a few outstanding questions for further research exploration:

1. Why do people in their late sixties and early seventies have higher MWB compared to a younger age or an older age?
2. Why do people have a steeply and steadily declined MWB in their late seventies and early eighties?

Possible explanations regarding these two questions that concluded from a previous review (chapter 4) are:

1. For older people around their late sixties and early seventies, they may have recovered well from their 'retirement blues' and got used to their new roles in later life. Their leisure activities and social engagement were well established compared to the early years with fewer health and financial concerns compared to later years (Alpass et al., 2000).

2. For older people around their late seventies and early eighties, physical health starts taking a vital role since the life expectancy in the UK is also around the early eighties (Cooper et al., 2011; Greenfield & Marks, 2004). Also, loneliness or loss may affect older people's mental health (Gouveia et al., 2017; Windle & Woods, 2004; Gow et al., 2007).
3. For oldest-old people around their nineties, the variations may be due to the limited sample. Using descriptive analysis to examine the variations lacks statistical significance. Future regression analysis is needed. Despite this, inter-personal differences may explain the variation. As physical health still plays a leading role (Cooper et al., 2011 & Ng et al., 2017), mental health regarding cognition and expectation also steps in (Schwandt, 2015). Besides, whether they receive caring support also significantly affect their MWB (Kadowaki et al., 2015).

To study MWB in old age, we need to exam the determinants of MWB. Detailed analysis of MWB determinants in older age is presented in the next chapter (Chapter 7).

# CHAPTER 7 THE DETERMINANTS & CONSEQUENCES OF MENTAL WELL-BEING IN OLD AGE: 9-YEAR LONGITUDINAL STUDY USING 'UNDERSTANDING SOCIETY' – THE UK HOUSEHOLD LONGITUDINAL STUDY (UKHLS)

## 7.1 INTRODUCTION

In this chapter, I investigate the epidemiology of mental well-being (MWB) in old age, from its determinants to its consequences. In addition, what is new to the current knowledge of MWB is whether MWB could mediate and moderate the association between later life risk factors and ageing well. Prior to this chapter, two parallel systematic reviews were conducted (Chapters 4 & 5). Previous research has derived some evidence of the association between potential determinants of MWB as well as associations between MWB and mortality and morbidity. However, several gaps still exist. First, the multifactorial association between MWB and its determinants has rarely been examined in a single study and hence the cumulative effects of these determinants on MWB remain uncertain. Second, there is a dearth of research on MWB consequences in old age included going beyond the associations with mortality. This chapter considers MWB consequences from the perspective of ageing well. As a reminder, ageing well is defined in this PhD as a state of doing, living and functioning well physically, psychologically and socially. Since MWB is an indicator of psychological wellness, a more robust analysis that pays particular attention to whether MWB could affect physically ageing well was undertaken. Quantitative analysis was used initially to determine the extent to which the observed variations in MWB could be explained by the list of potential determinants (later-life risk factors). It was also used to determine the predictive ability of MWB for ageing well (physically). Moreover, it was used to determine whether MWB could mediate and/or moderate the association between general health and physically ageing well.

The results presented in this chapter are based on secondary analysis of data collected as part of Understanding Society – the UK Household Longitudinal Study (UKHLS) over a period of up to 9 years. The quantitative analysis involved three steps. In step 1, the determinants of older people's MWB was analysed using multiple regression and mixed-effects modelling. In step 2, the association between MWB and its consequences on ageing well was analysed using a random-effects model. In step 3, the mediation effects of MWB were analysed using structural equation modelling (SEM) and a path analysis while the moderation effects of MWB were analysed using moderated multiple regression and logistic regression.

## 7.2 AIM, RESEARCH QUESTIONS AND HYPOTHESES

*Aim*

The overall aim of this PhD research is to discover whether mental well-being (MWB) influences outcomes associated with ageing and how it is associated with ageing well. Consequently, in this chapter, I will model the determinants and consequences of MWB in later life. The potential determinants were derived from a previous systematic review (Chapter 4) and separated into five categories: i) physical health & functioning, ii) social functioning, iii) behavioural & lifestyle, iv) psychological and v) demographic & socio-economic factors. Classifying potential aetiological factors in this way allows the investigation of multifactorial associations between MWB and its determinants. Secondly, it allows multiple regression analyses of dominant determinants of MWB. However, due to the data availability in the UKHLS, quantitative analyses undertaken in this chapter were only able to map and group three determinants categories, which were physical health, demographic & socio-economic and psychological categories. In addition, MWB consequences from the aspects of ageing well were only assessed using the 12-item short form health survey (SF-12) in the UKHLS. The SF-12 includes two subscales: physical health composite scores (PCS) and mental health composite scores (MCS), measuring individuals' physical wellness and psychological & social wellness respectively. As mentioned earlier, since MWB is an indicator of psychological wellness, the analyses of MWB consequences in old age in this chapter will focus on the association between MWB and SF-12 PCS. This chapter will add to the current knowledge of MWB consequences by providing evidence on whether MWB demonstrates a significant enhancing effect on physically ageing well, and moreover, whether MWB mediates and/or modifies the association between physical health and physically ageing well.

*Research questions*

To accomplish the research aim, I will firstly investigate the association between potential determinants and MWB in a longitudinal sample.

<u>Research Question 1</u>: What are the determinants of MWB in old age and to what extent do they explain the variations in MWB?

Second, I will explore the consequences of MWB on ageing well (physically).

<u>Research Question 2</u>: To what extent does MWB directly affect physically ageing well?

Third, I am interested in the underlying role that MWB might play in ageing well by examining whether MWB mediates and/or moderates the association between late life risk factors and physically ageing well.

Research Question 3: Does MWB mediate and/or moderate the association between physical health and physically ageing well?

*Hypotheses*

The overall hypothesis tested in this PhD is older people's MWB not only has direct influence on the ageing well processes, but also has indirect influence where MWB mediates and modifies the effect of other later-life risk factors on the ageing well processes (see Figure 44 below).

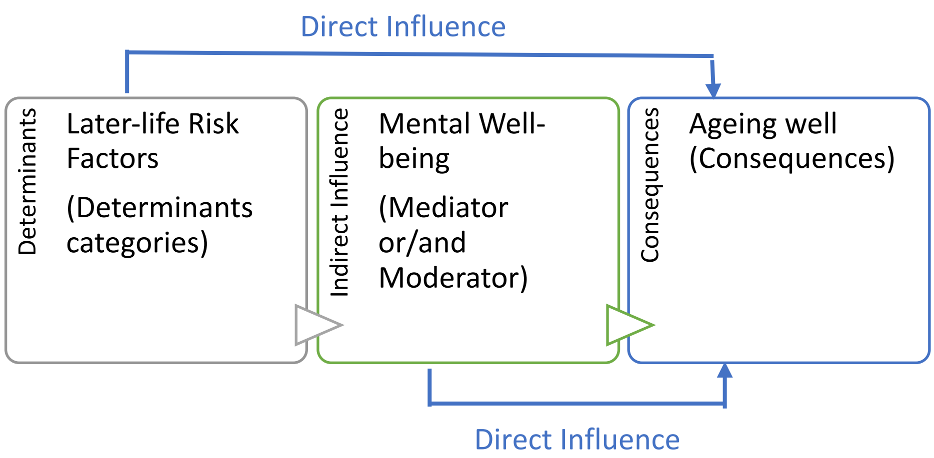



*Figure 44. Overall hypotheses*

The other hypotheses included in this chapter are:

1) Later-life risk factors will jointly associate with future MWB, of which ill health (physical and mental) dominate the negative effects of later-life risk factors on MWB;

2) MWB will promote ageing well not only through enhancing psychological wellness but also through enhancing physical wellness. Higher MWB predicts better physically ageing well even after controlling other later life risk factors;
3) MWB will mediate the association between physical health and ageing well. Higher MWB reduces the negative effect of physical health (indirectly) on physically ageing well; and
4) MWB will moderate the association between physical health and ageing well. Comparing people with the same level of physical health, those who have higher MWB predicts better physically ageing well.

## 7.3 METHODS

### 7.3.1 SAMPLE

*Understanding Society - The UK Household Longitudinal Study (UKHLS) wave1, wave4 and wave7 (maximum follow-up 9 years)*

The Understanding Society - the UK Household Longitudinal Study (UKHLS) 2009-2017 datasets consist of 3 waves that measured population MWB: wave1 2009-2011, wave4 2012-2014 and wave7 2015-2017. Each of the 3-wave datasets are downloaded from the UK data service under project ID 168037. The UK data service series code is 6614 for the all-inclusive datasets "Understanding Society: Waves 1-8, 2009-2017 and Harmonised BHPS: Waves 1-18, 1991-2009". The analysis undertaken combines individual (substantive data for responding adults (16+), including proxies) datasets and household (information for all persons in household, including children and non-respondents) datasets from each wave by a one-to-one match merge of cross-wave person identifier (pidp).

*Study sample from UKHLS wave1, wave4 and wave7*

The total observations included in UKHLS wave1, wave4 and wave7 were 77,309, 65,773 and 60,035, of which 13,963, 13,993 and 13,178 were aged 60+ respectively. The response rates of MWB questions were 67.32% in wave1, 77.58% in wave4 and 83.59% in wave7. In UKHLS wave1 (T1 baseline), 13,963 older people aged 60+ responded to the questionnaire, of whom 8,746 (62.64%) also responded to wave4 (T2) and 6,332 (45.35%) responded to all three waves (T1~T3) (see Figure 45 below). In addition, 12,744 (66.34%) older people responded to at least two waves. Since the interviews were carried throughout the three-year time period of each waves (wave1 2009-2011, wave4 2012-2014 and wave7 2015-2017), the minimum follow-up period for people responding for all three waves was 6 years and the maximum follow-up was 9 years.

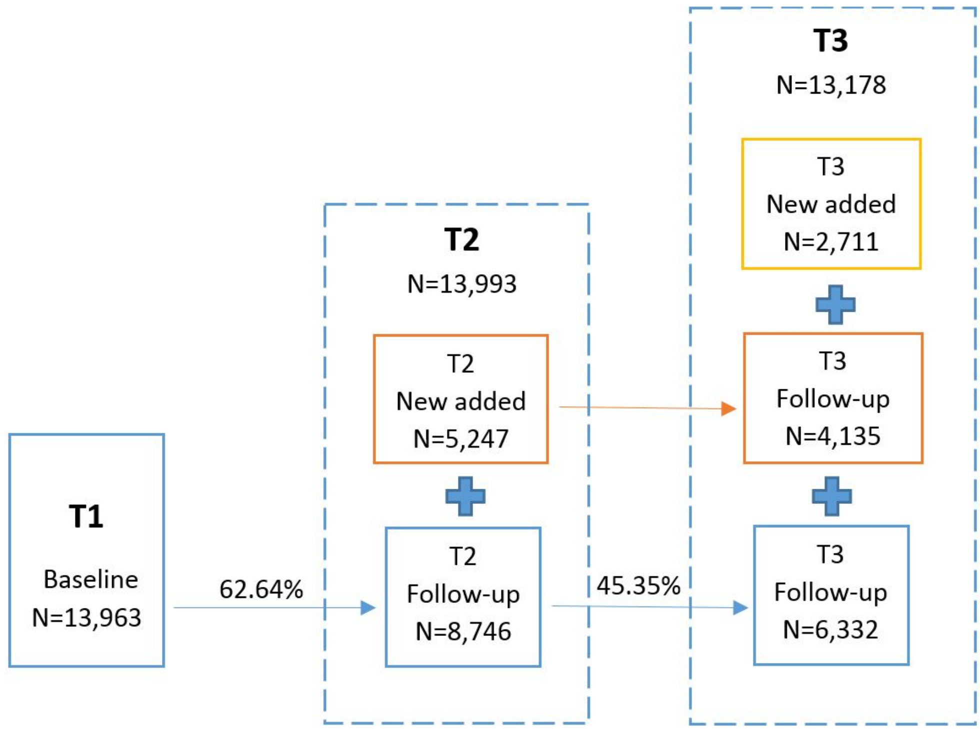



*Figure 45. Flow chart of follow-up in UKHLS, age 60+*

### 7.3.2 MEASURES

*Mental well-being*

MWB comprises both positive feelings (hedonic well-being) and positive functioning (eudaimonic well-being) (Stewart-Brown, 2015, 2018) and represents the positive aspect of mental health. The term, MWB, is also used to distinguish mental health from mental illness. The UKHLS included questions on MWB in self-completion questionnaires, which were administered on paper to adults aged 16+ during the face to face interview. Data on MWB was collected using the Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) (see Appendix A – Measures and scoring system), which was introduced in UKHLS wave1 2009 and continued to be used every three years. The SWEMWBS is a shortened version of the WEMWBS which uses 7 of the 14 items from the WEMWBS. SWEMWBS was developed to enable "the monitoring of mental wellbeing in the general population and the evaluation of projects, programmes and policies which aim to improve mental wellbeing" (Stewart-Brown, 2018b). The SWEMWBS scores are stored in numerical type for each of the 3 waves on a scale of 7-35. The scores are based on individuals' responses to 7 positive statements (score 7 for those who answer 'rarely' to all questions while score 35 for those who answer 'all of the time' to all questions). The higher the score, the greater the individual's MWB.

*Health outcome - ageing well – measured using SF-12*

Ageing well is defined in this PhD as a state of doing, living and functioning well physically, psychologically and socially. In this chapter, ageing outcomes were assessed using the 12-item short form health survey (SF-12) (see Appendix A - Measures and scoring system). The SF-12 includes 12 items covering 8 domains: general health, physical functioning, role functioning (physical), bodily pain, role functioning (emotional), mental health, vitality and social functioning (Ware et al., 1995, p. 11). The answers to the 12 questions are combined scored and weighted (using the regression coefficients from the general US population) to create two subscales (physical and mental health composite scores). Weighting variables improves the "linear fit" between physical health and mental health. The physical health composite scores (PCS) assess 4 domains including general health (1 item), physical functioning (2 items), role-physical (2 items) and bodily pain (1 item), while the mental health composite scores (MCS) assess the other 4 domains including role-emotional (2 items), mental health (2 items), vitality (1 item) and social functioning (1 item) (Ware et al., 1995, p. 19). PCS and MCS are based on orthogonal factor rotation which consider PCS and MCS to be distinct with very low correlation. In this chapter, physically ageing well is captured by SF-12 PCS (PCS). A SF-12 algorithm has been made to compute aggregate scores using positive weights for general health, physical functioning, role-physical and bodily pain, and negative weights for role-emotional, mental health, vitality and social functioning (Ware et al., 1995, pp. 21-25). The scores of PCS range from 0 to 100, where a zero score indicates the lowest level of health measured by the scales and 100 indicates the highest. Previous research has also tested validity and reliability on measuring quality of life among older people (Jakobsson, 2008). Nonetheless, the SF-12 PCS is anticipated to be closely correlated to general health since an individual's self-assessed general health is used in the SF-12 PCS general health subdomain.

*Risk factors – grouped by three categories: physical health, demographic & socio-economic and psychological categories*

In line with the systematic review (Chapter 4), potential risk factors were grouped to five categories: physical health & functioning, social functioning, behavioural & lifestyle, psychological and demographic & socio-economic. However, due to the data available in the UKHLS, quantitative analyses undertaken in this chapter were only able to map and group three of them, which were physical health, socio-demographic and psychological categories.

Physical health category – measured by general health and chronic conditions

*General health*

General health (self-assessed general health) is measured by asking people to rate their health as "excellent, very good, good, fair or poor".

*Chronic conditions*

Chronic conditions are measured by asking people to tick the diagnosed health conditions they have (from a list of 17 chronic conditions). The analysis undertaken in this chapter grouped the number of chronic conditions as: "no listed, 1, 2, 3-4 and 5 or more". Although the same questions were asked in each wave in the UKHLS ("Has a doctor or other health professional ever told you that you have any of the conditions listed on this card? Please just tell me the numbers that apply"), individuals' replies to the number of diagnosed health conditions showed a great difference among wave1 and waves 4&7. In wave 4 and wave 7, most individuals replied "inapplicable" to this question. This may indicate a potential response bias in the UKHLS.

Demographic & socio-economic category – measured by age, sex, financial situation, education, marital status, employment status, and religion

*Age*

The original variable of age groups in UKHLS put all older people aged 70+ together. As concluded from Chapter 6, there are more variations in MWB distribution among older people in advanced age. Therefore, a new variable of age 60+ at approximately 3-year bands, was generated for each of the three waves. In consideration that people aged 84 and above will be all over 90 after three waves, the age variable hence consists of 9 inclusive age groups: 60-62, 63-65, 66-68, 69-71, 72-74, 75-77, 78-80, 81-83 and 84+.

*Financial situation*

Financial situation is measured by asking older people how well they managed financially. The answers may be: "living comfortably, doing alright, just about getting by, finding it quite difficult or finding it very difficult".

*Education*

This chapter uses "highest qualification ever reported" as the measure of education. The analysis undertaken grouped education as: "Degree or other higher; A-level & GCSE etc; other qualification and no qualification".

*Marital status*

This chapter uses "*De facto* marital status" as the measure of marital status. The analysis undertaken grouped marital status to 3 groups as "married, in a partnership or cohabit; single, separated or divorced; and widowed".

*Employment status*

This chapter uses "current economic activity" as the measure of employment status. The analysis undertaken grouped employment status as: "employed; retired and other inactive (including unemployed and not looking for jobs)". Since this PhD is focused on older people, a majority of the sample included in the analysis were retired (over 70%). In addition, in the UKHLS sample, older people reported in an unemployed status were extremely small in numbers (1%). Hence, the analysis undertaken also grouped this very small number of unemployed older people into ‘other inactive’ group.

*Religion*

This chapter uses the binary measure of religion by asking older people whether they belong to a religion.

*<u>Psychological category - measured by mental illness and sleep quality</u>*

*Mental illness*

The 12 questions of the General Health Questionnaire (GHQ-12) are used to detect psychiatric disorders in the general population within the community. The questionnaire was developed as a screening tool to measure mild somatic and psychological symptoms (Goldberg & William, 1988). It assesses people’s current mental state and asks if it differs from their usual state. The higher the score, the more severe the condition (Hankins, 2008). In the UKHLS, GHQ-12 questions are asked with both positive and negative items along with positive and negative answer options. In order to best capture mental illness, the GHQ-12 caseness variable is used in the analysis. As an indication of 'caseness', the scores are converted into a binary score, such that answers indicating positive mental health = 0, answers indicating negative mental health = 1. (see Appendix A. Measures and scoring system). The GHQ-12 caseness converts valid answers to a single scale running from 0 (the least distressed) to 12 (the most distressed). Although there is no universally used threshold score for GHQ-12, most studies agree with a threshold score of 4 as the suggested level for identifying cases of mental illnesses (Jackson, 2007). Knott

(2012) also indicated that a threshold score of 4 is used in the Health Survey England (HSE) reports. Hence this PhD tallied with the HSE reports and groups participants' scores to three categories: 0: no evidence of probable mental illness, 1-3: less than optimal mental health, and 4 or more: probable psychological disturbance or mental illness (Knott, 2012).

*Sleep quality*

In the UKHLS, overall sleep quality is measured by asking people to rate their sleep quality as "very good, fairly good, fairly bad and very bad".

### 7.3.3 DESIGN & ANALYSIS STRATEGIES

With the intention of addressing the research aim, the quantitative analysis undertaken in this chapter used a number of statistical approaches. First, using multiple regression and mixed-effects model to examine the cross-sectional and the longitudinal associations between potential determinants and MWB. Second, using a random-effects model to examine the consequences of MWB. Third, using structural equation modelling (SEM) and path analysis to examine the mediation effects of MWB and using multiple regression and logistic regression to examine the moderation effects. All statistical analysis was carried out via Stata 15. V2. The detailed design of the analytic strategy is listed as below.

*Determinants of MWB*

The aim of the analysis is to specify an MWB function such that the natural logarithm of MWB is a function of individual level health and social variables that are either more time-variant or more time-invariant. The natural logarithm is preferred because coefficients on the natural-log scale are directly interpretable as approximate proportional differences (Gelman & Hill, 2007). A testable MWB function can be represented as follows:

$$MWBt = Xit\,\boldsymbol{\beta}i + Zi\,\boldsymbol{\gamma}i + \boldsymbol{\eta}it + \boldsymbol{\alpha}i \text{ (equation 1)}$$

i=1, 2, 3…N; t=1, 2, 3 …T, where i indexes individuals and t indexes time period (waves of UKHLS).

Where: MWBt represents the logarithm of MWB at each time period;

Xit is a set of time-variant regressors including general health, chronic conditions, age, financial situation, marital status, employment status, overall sleeping quality and mental illness;

Zi is a set of time-invariant regressors for older people including sex, education, and religion;

$\boldsymbol{\beta}$i is a set of time-variant vectors of parameters and;

$\gamma$i is a set of time-invariant vectors of parameters.

The two error terms, $\boldsymbol{\alpha}$i and $\boldsymbol{\eta}$i are assumed to be normally distributed with zero means.

$\boldsymbol{\eta}$i is an individually specific time-variant error term and;

$\boldsymbol{\alpha}$i is an individually specific time-invariant error term.

Cross-sectional analysis using multiple regression with three sets of regressors (physical health, demographic & socio-economic and psychological factors) was initially performed. The aim of multiple regression was to include all determinants that are clearly associated with MWB in the estimated MWB function and identify the dominant determinants of MWB in old age.

Longitudinal analysis using multilevel modelling was then conducted. In addition to the cross-sectional analysis that identified the determinants of (risk factors associated with) MWB, longitudinal analysis was also aimed at determining individual patterns of change in older people's MWB. In this chapter, initially, both the random-effects and the fixed-effects model were conducted (see Appendix C. Secondary Analyses – 3. Additional results tables – 3.2 Longitudinal analysis – multilevel modelling: Fixed-effects vs Random-effects) with the Hausman test also examined. The result from the Hausman test (chi2=459.74, p<0.001) suggested a fixed-effects model is preferred over a random-effects model. However, in the fixed-effects hypothesis, MWB is associated with time-variant determinants only but not time-invariant determinants. A limitation of using a fixed-effects model is that it could not investigate time-invariant (including sex, education and religion) causes of MWB.

On the other hand, in the random-effects hypothesis, MWB is associated with both time-variant determinants and time-invariant determinants. Although random-effects hypothesis meets the analysis needs, a random-effects model was not preferred by the Hausman test. In addition, a random-effects model might suffer from exogenous time-variant regressors, since it assumes exogeneity of all the regressors and the random individual effects. A new random-effects model including within and between (w/b) effects was also generated with w/b effects tested. Significantly different results suggested that one or more time-variant regressors were endogenous (see Appendix C. Secondary Analysis – 3. Additional results tables – 3.3 Longitudinal analysis – multilevel modelling: Random-effects, Hausman-Taylor vs Fixed-effects), in other words a random-effects model was not preferred either. In this case where both time-variant and time-invariant variables are of interest, a mixed-effects model provided the best option; the Hausman-Taylor model that combines the consistency of a fixed-effects model with the efficiency and applicability of a random-effects model was finally performed in the main results section.

*Consequences of MWB*

A random-effects model was conducted to investigate the consequences of MWB on physically ageing well (measured by SF-12 PCS). This can be represented as follows:

$$\text{SF-12 PCS}_t = \text{MWB}_{it-1}\,\boldsymbol{\rho}_{t-1} + Y_{it-1}\,\boldsymbol{\theta}_{it-1} + \boldsymbol{\varepsilon}_t \text{ (equation 2)}$$

i=1, 2, 3…N; t=1, 2, 3 …T, where i indexes individuals and t indexes time period (waves of UKHLS).

> SF-12 $PCS_t$ is the measure of physically ageing well at each time period;
>
> $MWB_{it-1}$ is the time-lagged MWB;
>
> $\boldsymbol{\rho}_{t-1}$ is the random-effects estimator that explains the variation of SF-12 $PCS_t$ by time-lagged MWB;
>
> $Y_{t-1}$ is a set of controlled demographic & socio-economic and psychological covariates including age, financial situation, marital status, employment status, overall sleeping quality and mental illness;
>
> $\boldsymbol{\theta}_{t-1}$ as a set of vectors of parameters of these controlled covariates;
>
> $\boldsymbol{\varepsilon}_t$ is the error term that is assumed to be normally distributed with zero means.

The random-effects model also excluded general health to avoid multicollinearity.

*Mediation effects of MWB*

Mediation analysis investigates whether a mediator accounts for a significant association between the independent and the dependent variable. It focuses on the changes of a previously significant association between the independent and dependent variables after adding the mediator. In order to find out whether MWB mediated the association between later life risk factors and physically ageing well, a structural equation modelling (SEM) was used. In this chapter, a longitudinal mediation model and a path mediation model were designed to investigate the mediation effect. A path diagram presented with β estimates was initially designed to explain the longitudinal associations (see Figure 46 below).

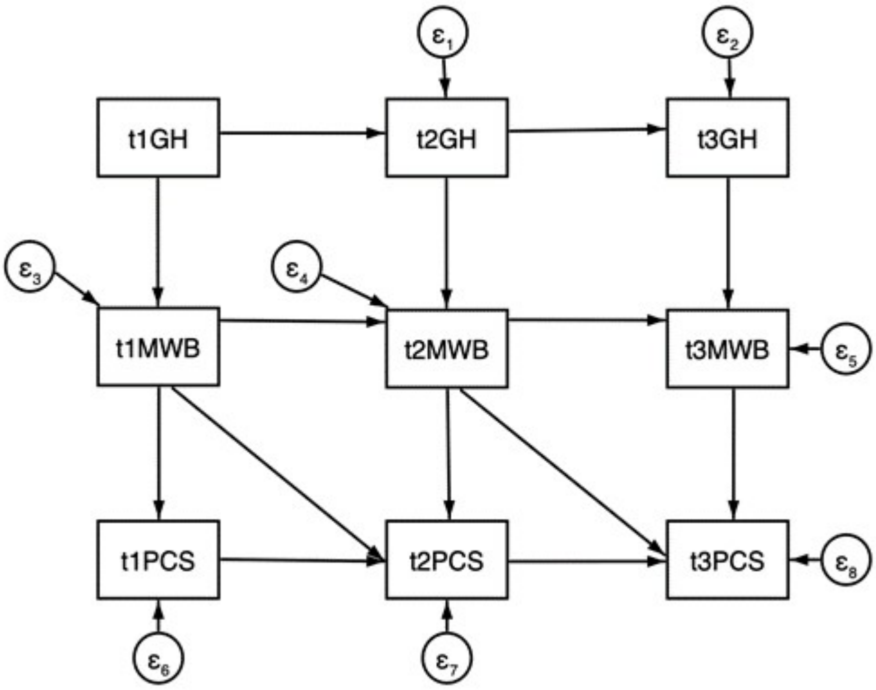



*Figure 46. Path diagram – β estimates (design)*

In the mediation effects analyses, the dependent variable was SF-12 PCS (PCS) while the independent variables were general health (GH) and time-lagged PCS. The mediating variables were MWB and time-lagged MWB. In the longitudinal mediation model, the longitudinal (accumulated) mediation effects between GH and PCS through MWB and time-lagged MWB, and between time-lagged PCS and PCS through MWB and time-lagged MWB were examined. In the path mediation model, each path was presented with the estimated direct effect, total effect and the indirect effect (see Figure 47 below: D for direct effect, I for indirect effect and T for total effect). The indirect effect indicated the mediation effect that MWB and time-lagged MWB have on the association between the dependent variable and the independent variables.

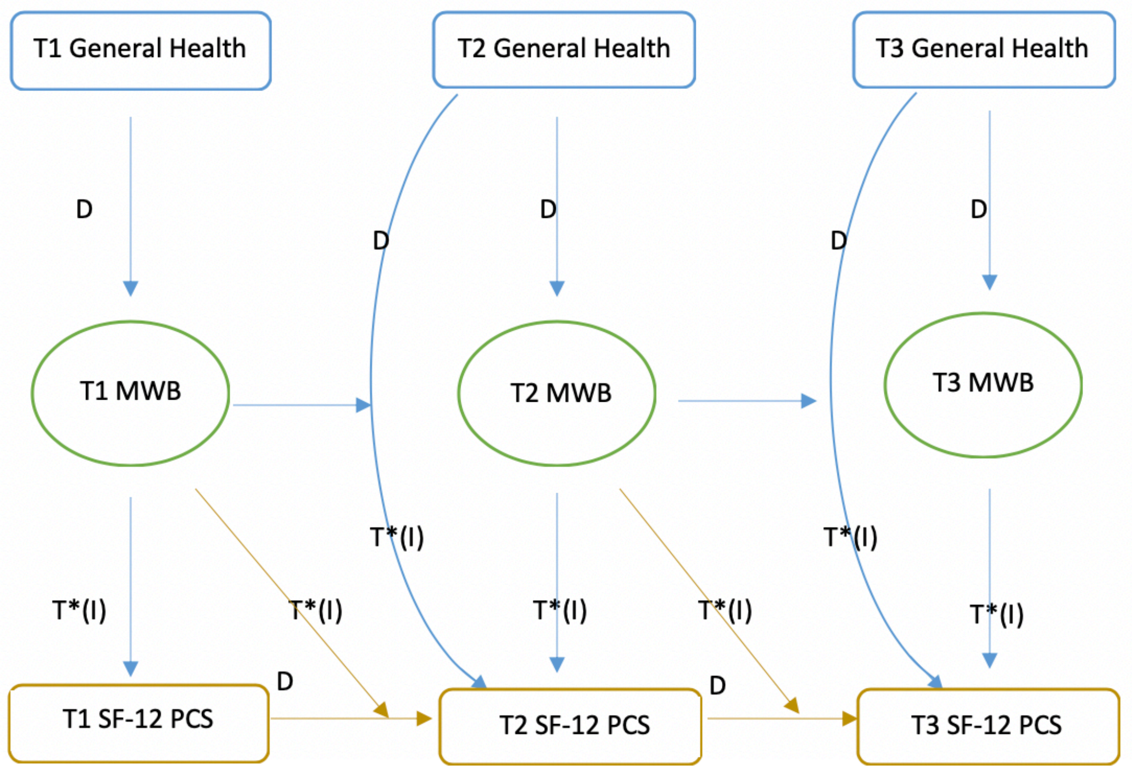



*Figure 47.Mediation effect – path model (design), D for direct effect, I for indirect effect and T for total effect*

<u>*Moderation effects of MWB*</u>

A moderator moderates the association between independent and dependent variables. It focuses on the significance of the interaction of the independent variable and moderator in association with the dependent variable. In this chapter, a dichotomous moderator variable (lower or upper quartile MWB) modified the association between a continuous dependent variable (current PCS) and continuous independent variable (previous GH or previous PCS). Hence, instead of the original regression analysis using continuous MWB and PCS, the moderation effects analysis grouped MWB and PCS by quartiles. The analysis using dichotomous MWB (compare lower quartile vs upper quartile) would initially reduce half of the sample size. In order to find out whether a previous MWB level could moderate this association, a pooled time-lagged multiple regression analysis and robust logistic regression was used. Additionally, the moderation effects were also presented in graphs. The slope differences between lower quartile MWB group and upper quartile MWB group suggested different levels of MWB modified the associations differently.

*Lost to follow-up*

The high lost to follow-up or drop-out rate of older people in UKHLS is more likely to be related to health reasons, including death, hospitalisation, care home admission and physically or mentally unable to response (Jones et al., 2013). Therefore, the analysis assumed MWB was an indicator of surviving from the listed potential adverse events and tested whether older people remaining in this UKHLS up to 9-years' follow-up study had a higher level of MWB even after controlling for other confounders.

A Kaplan-Meier curve estimation and Kaplan-Meier curve of follow-up were examined, with a Log-rank test also performed. In addition, a Cox proportional hazards model was also undertaken. The Cox proportional hazards model assumed that the hazard of lost to follow-up/drop-out rate in each MWB quartiles was constant over the time of follow-up. The hazard ratio compared the drop-out older people during T1 & T2 with the remaining older people followed up to 9 years (T1~T3). In order to test the overall hypotheses proposed in this PhD, a Cox regression analysis on the single effects of MWB on survival (protection of adverse events related to loss of follow-up) was used. Besides, a Cox regression analysis on the effects of MWB, and effects of MWB determinants (influencing factors) on lost to follow-up was also examined in order to test whether MWB brings extra benefits on survival even after controlling the other influential factors.

## 7.4 RESULTS

### 7.4.1 CHARACTERISTICS OF RESPONDENTS

The main baseline (T1) characteristics of respondents that followed up to 9 years are summarised in Table 20 below. The total sample included 6,332 community dwelling older people aged 60+ in the UK.

*Table 20.Characteristics of respondents - UKHLS 3 waves' longitudinal datasets*

| **Variable at baseline T1** **(Total Observations followed up to 9 years: N=6,332)** | **Frequency (n)** | **Percentage (%)** |
|---|---|---|
| **Age (N=6,332)** | | |
| 60-62 | 1,394 | 22.02 |
| 63-65 | 1,264 | 19.96 |
| 66-68 | 971 | 15.33 |
| 69-71 | 841 | 13.28 |
| 72-74 | 681 | 10.75 |
| 75-77 | 465 | 7.34 |
| 78-80 | 345 | 5.45 |
| 81-83 | 212 | 3.35 |
| 84+ | 159 | 2.51 |
| **Sex (N=6,332)** | | |
| Male | 2,979 | 47.05 |
| Female | 3,353 | 52.95 |
| **General Health (N=5,973)** | | |
| Excellent | 801 | 13.41 |
| Very good | 1,765 | 29.55 |
| Good | 1,788 | 29.93 |
| Fair | 1,136 | 19.02 |
| Poor | 483 | 8.09 |
| **Chronic Disease (N=5,787)** | | |
| No listed CD | 1,532 | 26.47 |

| | | |
|---|---|---|
| 1 | 2,044 | 35.32 |
| 2 | 1,227 | 21.20 |
| 3-4 | 816 | 14.10 |
| 5 or more | 168 | 2.90 |
| **Marital Status (N=6,330)** | | |
| Married, in a partnership or cohabit | 4,383 | 69.24 |
| Single, Separated or Divorced | 929 | 14.68 |
| Widowed | 1,018 | 16.08 |
| **Living Status (N=6,332)** | | |
| Live with cohabitant or spouse | 4,367 | 68.97 |
| Live alone | 1,965 | 31.03 |
| **Employment Status (N=5,781)** | | |
| Employed | 1,218 | 21.07 |
| Retired | 4,235 | 73.26 |
| Other inactive (including unemployed and not looking for a job) | 328 | 5.67 |
| **Income (N=5,983)** | | |
| Less than 500 | 1,344 | 22.46 |
| 500-1000 | 1,938 | 32.39 |
| 1000-2000 | 1,971 | 32.94 |
| 2000-5000 | 637 | 10.65 |
| 5000 or more | 93 | 1.55 |
| **Financial situation (N=5,776)** | | |
| Living comfortably | 2,311 | 40.01 |
| Doing alright | 1,832 | 31.72 |
| Just about getting by | 1,323 | 22.91 |
| Finding it quite/very difficult | 310 | 5.37 |
| **Education (N=5,980)** | | |
| Degree or other higher | 1,626 | 27.19 |
| A level & GCSE etc | 1,596 | 26.69 |
| Other qualification | 970 | 16.22 |
| No qualification | 1,788 | 29.90 |
| **Religion (N=5,787)** | | |
| Yes | 3,990 | 68.95 |
| No | 1,797 | 31.05 |
| **Overall sleep quality (N=5,163)** | | |
| Very good | 1,588 | 30.76 |
| Fairly good | 2,738 | 53.03 |
| Fairly bad | 684 | 13.25 |
| Very bad | 153 | 2.96 |
| **GHQ-12 caseness (N=6,332)** | | |
| 0 | 3,284 | 51.86 |
| 1-3 | 1,196 | 18.89 |
| 4 or more | 1,852 | 29.25 |

| | | |
|---|---|---|
| **Ethnicity (N=6,094)** | | |
| White | 5,695 | 93.45 |
| Asian or Asian British | 210 | 3.45 |
| Black or black British | 133 | 2.18 |
| Mixed | 30 | 0.49 |
| Other ethnic groups | 26 | 0.43 |
| **Urban Status (N=6,332)** | | |
| Urban area | 4,453 | 70.33 |
| Rural area | 1,879 | 29.67 |
| **Quality of Life: SF-12 Physical Component Summary (PCS) (N=5,753)** | | |
| Mean (95% CI) | **45.62 (45.30 ~ 45.94)** | |
| Range | **4.56 – 74.46** | |
| **Quality of Life: SF-12 Mental Component Summary (MCS) (N=5,753)** | | |
| Mean (95% CI) | **52.99 (52.75 ~ 53.23)** | |
| Range | **1.61 – 77.11** | |
| **Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) (N=4,851)** | | |
| Mean (95% CI) | **26.46 (26.34 ~ 26.58)** | |
| Range | **7 – 35** | |

Before data analysis, a non-response bias analysis on SWEMWBS questions was also performed. The simple variable addition tests (Jones et al., 2013 adapted from Verbeek and Nijman, 1992) were used to test statistical significance on the association between MWB and its determinants by adding dummy variables to the pooled random-effects model. These test results rejected the null hypothesis, suggesting that there was a problem of attrition bias. In this PhD, the attrition bias might be caused by the "healthy survivors"; in other words, older people who repeated during follow-ups generally had a higher level of MWB than those lost to follow-up. A lost to follow-up analysis was therefore performed. Both a Kaplan-Meier curve of follow-up and a Cox proportional hazards model suggested that the higher the MWB, the higher the possibility that older people remained in the follow-up (see Appendix C. Secondary Analyses – 4. Lost to follow-up analysis). The results of lost to follow-up will be presented at the end of this chapter.

### 7.4.2 DETERMINANTS

As summarised in Chapter 4, physical health and mental illness are the dominant factors associated with MWB, where social functioning and socio-demographic factors have subtle influences on MWB. The quantitative study in this chapter examined the predictive ability of physical health, psychological and demographic & socio-economic factors of MWB in old age.

#### *7.4.2.1 Distribution of MWB – slightly left skewed*

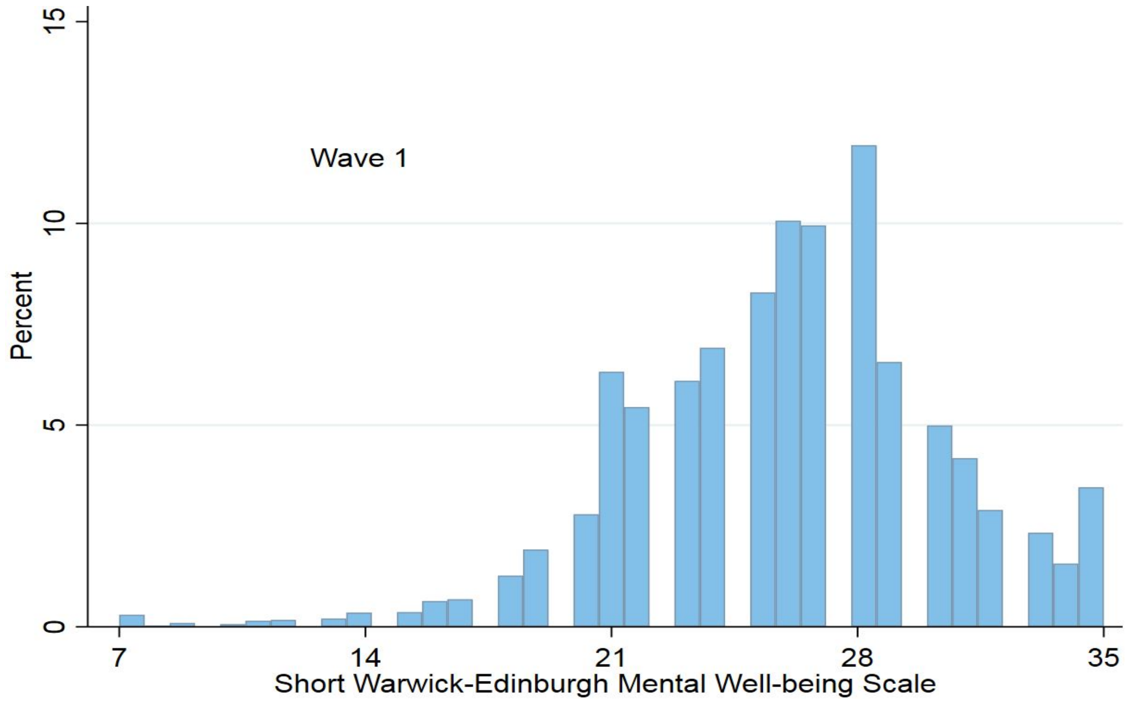



*Figure 48. MWB distributions in wave1 baseline*

In order to find out a suitable method to specify MWB function, the distribution of MWB was first performed. From the histogram for wave1 baseline (see Figure 48 above), we can see that MWB is slightly left skewed. The Shapiro-Wilk W test also rejected the null hypothesis that MWB is normally distributed. Hence, the ordinary least squares (OLS) model was rejected as it cannot predict the association between MWB and its determinants precisely. At the same time, hettest, ovtest and linktest were also performed to test heteroscedasticity. As a result, there was insufficient evidence to reject the null hypothesis that a linear model of MWB does not suffer from omitted variables. Hence non-linear models were more suitable in the analysis. As neither variance-weighted regression nor poisson regression was suitable for MWB function, the association between potential determinants (categorical independent variables) and MWB (continuous dependent variables) was examined by analysis of variance and covariance (N-way ANOVA).

#### *7.4.2.2 Cross-sectional analysis – multiple regression*

With the intention of identifying the potential regressors from UKHLS datasets, pairwise correlation of potential determinants and SWEMWBS were analysed first (Appendix C. Secondary Analyses – 2. Pairwise correlation at T1, T2 and T3). The factors that have a higher correlation with MWB are GHQ-12 (range from -0.4964 to -0.4260), general health (range from -0.3791 to -0.3108), overall sleep quality (range from -0.3454 to -0.3010), and financial situation (range from -0.2570 to -0.2131). The correlation between baseline GHQ-12 caseness and SWEMWBS was -0.4905, which confirmed a similar moderate correlation as Tennant et al. (2007) demonstrated. Potential determinants of MWB could be grouped into physical health (including general health and chronic conditions), demographic & socio-economic factors (including age, sex, financial situation, married status, education, employment status and religion) and psychological factors (including overall sleep quality and GHQ-12).

In the cross-sectional analysis, multiple regression with these three sets of potential determinants was performed. The aim of the multiple regression was to include all determinants that are clearly associated with MWB in old age, in the hope of increasing the precision of the estimated MWB function. Before multiple regression analysis, homoscedasticity and no show of multicollinearity had also been tested. The results from the pooled sample (3 waves) multiple regression were presented in Table 21 below, while separate analyses for each wave were presented in Appendix C. Secondary Analyses – 3. Additional results tables – 3.1 Cross-sectional analysis.

*Table 21. Multiple regression results - pooled sample*

| | Multiple regression results - pooled sample (p-value) 95%CI | | |
|---|---|---|---|
| **Determinants** | **Pooled (PH only)** | **Pooled (PH+DS)** | **Pooled (PH+DS+PF)** |
| **R-squared (adjusted R-squared)** | **12.60% (12.58%)** | **15.57% (15.51%)** | **28.37% (28.30%)** |
| **General Health** | | | |
| Excellent (ref) | | | |
| Very good | **-0.0375 (0.000)** | **-0.0349 (0.000)** | **-0.0250 (0.000)** |
| Good | **-0.0852 (0.000)** | **-0.0766 (0.000)** | **-0.0494 (0.000)** |
| Fair | **-0.1495 (0.000)** | **-0.1301 (0.000)** | **-0.0726 (0.000)** |
| Poor | **-0.2496 (0.000)** | **-0.2125 (0.000)** | **-0.1036 (0.000)** |
| **Age** | | | |
| 60-62 (ref) | | | |
| 63-65 | | **0.0108 (0.003)** | **0.0078 (0.019)** |
| 66-68 | | **0.0189 (0.000)** | **0.0112 (0.002)** |
| 69-71 | | **0.0210 (0.000)** | **0.0124 (0.001)** |
| 72-74 | | **0.0250 (0.000)** | **0.0159 (0.000)** |
| 75-77 | | **0.0221 (0.000)** | **0.0139 (0.001)** |
| 78-80 | | **0.0165 (0.001)** | 0.0076 (0.100) |
| 81-83 | | **0.0131 (0.020)** | 0.0070 (0.179) |
| 84+ | | -0.0060 (0.263) | -0.0080 (0.108) |
| **Sex** | | | |
| Male (ref) | | | |
| Female | | **-0.0107 (0.000)** | **0.0053 (0.007)** |
| **Financial situation** | | | |
| Living comfortably (ref) | | | |
| Doing alright | | **-0.0292 (0.000)** | **-0.0229 (0.000)** |
| Just about getting by | | **-0.0540 (0.000)** | **-0.0349 (0.000)** |
| Finding it quite/very difficult | | **-0.1170 (0.000)** | **-0.0640 (0.000)** |
| **Marital Status** | | | |
| Widowed (ref) | | | |
| Single, Separated or Divorced | | -0.0016 (0.666) | -0.0030 (0.372) |
| Married, in a partnership or cohabit | | **0.0087 (0.004)** | **0.0063 (0.022)** |
| **Employment Status** | | | |
| Inactive (including unemployed) (ref) | | | |
| Retired | | **0.0364 (0.000)** | **0.0224 (0.000)** |
| Employed | | **0.0362 (0.000)** | **0.0185 (0.000)** |
| **Education** | | | |
| No qualification (ref) | | | |
| Other qualification | | 0.0041 (0.203) | 0.0049 (0.100) |
| A level & GCSE etc | | 0.0024 (0.393) | 0.0041 (0.109) |
| Degree or other higher | | **0.0079 (0.007)** | **0.0120 (0.000)** |
| **Religion** | | | |
| No (ref) | | | |
| Yes | | **0.0129 (0.000)** | **0.0121 (0.000)** |
| **Overall sleep quality** | | | |
| Very good (ref) | | | |
| Fairly good | | | **-0.0380 (0.000)** |
| Fairly bad | | | **-0.0613 (0.000)** |

Note: all results in **bold** p<0.05; **PH** represented physical health, **DS** represented demographic & socio-economics factors, **PF** represented psychological factors

While the initial model estimating the effects of physical health could explain 12.60% ($p<0.001$) of the variability of MWB in the pooled sample, the effects of demographic & socio-economic factors could explain a further 2.97% ($p<0.001$) of the variability. A significant improvement of 12.8% could be detected when the psychological effects has been taken into account. The complete model of physical health (PH), demographic & socio-economic (DS) and psychological factors (PF) could explain 28.37% ($p<0.001$) of the variability of MWB in total. Similar results are also demonstrated in each wave (see Appendix C. Secondary Analyses – 3. Additional results tables – 3.1 Cross-sectional analysis – multiple regression T1, T2 & T3).

In this complete model (PH+DS+PF as presented in Table 21above), mental illness is the most influential factor over all other factors associated with older people's MWB. GHQ-12>=4 (as an indicator for mental illness) compared with GHQ-12=0 (no evidence of probable mental illness) is associated with significantly lower MWB ($B=-0.1925$, $P<0.001$). General health is demonstrated to be the second most influential factor. The worse the self-assessed general health, the lower older people's MWB. Compared with the reference groups, a worse financial situation is also associated with a significantly lower MWB. On the other hand, having a degree or higher qualifications, being married and being religious are associated with significantly higher MWB. Compared with older people who reported being in an inactive (including unemployed) situation, those retired and those in paid employment all present significantly higher MWB. Being a woman is associated with significantly higher MWB in the complete model (PH+DS+PF) but a significantly lower MWB in the PH+DS model. This inconsistent result is also presented across each wave (also see Appendix C. Secondary Analyses – 3. Additional results tables – 3.1 Cross-sectional analysis – multiple regression T1, T2 & T3).

However, a difference in the components of the estimated model (determinants) of MWB between the pooled sample and separate waves were detected. In the pooled sample, the chronic conditions variable had been removed from the PH category since it reduced the explanation power of the estimated model. Moreover, in the T1 complete model, compared to older people who reported having no chronic conditions, having two diagnosed chronic conditions was associated with a slightly higher MWB ($B=0.0118$, $p<0.031$) (see Appendix C. Secondary Analyses – 3. Additional results tables – 3.1 Cross-sectional analysis – multiple regression T1, T2 & T3). Nevertheless, this correlation between chronic conditions and MWB might not have meaningful interpretation as a result of the response bias mentioned before in the methods – measures section (7.3.2) of this chapter (see Appendix C. Secondary Analyses – 2. Data preparation-chronic conditions for detail).

In this chapter, cross-sectional regression analysis results also confirmed that the association between older age and MWB displays a slightly inverted 'U-shape' (convex relationship) even after controlling for physical health and demographic & socio-economic factors. The previous chapter (chapter 6) on the age-MWB association only used descriptive analysis without controlled covariates. The cross-sectional regression analysis provides additional empirical evidence on the inverted 'U-shape' in old age by also controlling demographic & socio-economic and general health. When taking into account psychological effects, although it has lost its statistical significance in three advanced age groups, the association between older age and MWB still displayed a slightly inverted 'U-shape' (convex relationship) between age 60 and 77.

### *7.4.2.3 Longitudinal analysis – mixed-effects modelling*

Longitudinal association between these factors and older people's MWB were also tested. As explained in the methods – design section (7.3.3), risk factors associated with older people's MWB were considered as time-variant regressors including general health, chronic conditions, age, financial situation, marital status, employment status, overall sleeping quality and mental illness; and a set of time-invariant regressors of older people including sex, education and religion. In the longitudinal analysis, multilevel modelling was performed with random-effects, fixed-effects and Hausman-Taylor models all being tested (see Appendix C. Secondary Analyses – 3. Additional results tables – 3.3 Longitudinal analysis – multilevel modelling: Random-effects, Hausman-Taylor vs Fixed-effects). In consideration of the response bias of chronic conditions also affecting the estimated MWB function longitudinally, further analysis also excluded chronic conditions from the global determinants of MWB.

As explained and tested in the methods – design section (7.3.3) of this chapter, neither the random-effects nor the fixed-effects model could best explain the model of MWB in the longitudinal setting. In this case, a Hausman-Taylor (mixed effects) model was preferred. The Hausman-Taylor (1981) model allows some of the explanatory variables to be correlated with the individual effects and assumes both time-variant and time-invariant regressors can be classified as either endogenous (determined by the model) or exogenous (determined outside the model). It combines the consistency of a fixed-effects model with the efficiency and applicability of a random-effects model. The findings from a fixed-effects model suggest ill-health (both physically and mentally), poor financial situation, poor sleep quality, being widowed and being inactive or unemployed are all associated with lower MWB in the long term (see Appendix C. Secondary Analyses – 3. Additional results tables – 3.3 Longitudinal analysis – multilevel modelling: Random-effects, Hausman-Taylor vs Fixed-effects). The Hausman-Taylor model also suggests being female, having higher qualification level and being religious all relate to higher MWB in the long term (see Table 22 below). In addition, it suggests 45.97% of the variance is due to differences across waves. The statistically insignificant effect of advanced age on MWB does not indicate no association between age and MWB but might rather suggest a non-linear association (convex relationship as analysed in the cross-sectional setting in the last section and in the random-effects model in the longitudinal setting, see Appendix C. Secondary Analyses – 3. Additional results tables – 3.2 Longitudinal analysis – multilevel modelling: Fixed-effects vs Random-effects).

*Table 22.Mixed-effects model: Hausman-Taylor model*

| | Hausman-Taylor | | |
|---|---|---|---|
| | **Est** | **(SE)** | **P value** |
| **Fixed part (β)** | | | |
| General Health | **-0.017** | **(0.002)** | **0.000** |
| Age | -0.001 | (0.001) | 0.509 |
| Sex | **0.010** | **(0.003)** | **0.000** |
| Financial situation | **-0.016** | **(0.002)** | **0.000** |
| Marital Status | **0.010** | **(0.002)** | **0.000** |
| Employment Status | **0.013** | **(0.003)** | **0.000** |
| Education | **0.008** | **(0.001)** | **0.000** |
| Religion | **0.016** | **(0.003)** | **0.000** |
| Overall sleep quality | **-0.018** | **(0.002)** | **0.000** |
| GHQ-12 caseness | **-0.057** | **(0.002)** | **0.000** |
| **[_con]** | **3.310** | **(0.014)** | **0.000** |
| **Random part** | | | |
| **SD (_con) or ς_u** | **0.119** | | |
| **SD (residual) or ς_e** | **0.129** | | |

Note: all results in **bold** p<0.05; Separate within and between effects; coefficients of cluster mean not shown

In order to test whether the previous level of MWB could significantly affect the β estimates of the determinants of MWB, a lagged response model is also performed (see Table 23 below, in comparison with the general OLS model). The main (most influential) determinants of MWB: general health, financial situation, sleep quality and mental illness maintain their statistical significance and predict negative association with MWB in the lagged-response model. On the other hand, the β estimates of religion maintain its statistical significance and predict a positive association with MWB. The result is typical in the lagged-response model as all associations with risk factors became smaller when controlling for previous MWB. Furthermore, the β estimates of age, sex, marital status and education level lost their statistical significance after controlling for previous MWB.

*Table 23.Lagged-response model*

| | OLS | | | Exogenous lag (OLS) | | |
|---|---|---|---|---|---|---|
| | Est | (SE) | P value | Est | (SE) | P value |
| **Fixed part (β)** | | | | | | |
| General Health | **-0.025** | **(0.001)** | **0.000** | **-0.016** | **(0.001)** | **0.000** |
| Age | **0.001** | **(0.000)** | **0.002** | -0.001 | (0.001) | 0.094 |
| Sex | **0.006** | **(0.002)** | **0.001** | 0.002 | (0.003) | 0.555 |
| Financial situation | **-0.020** | **(0.001)** | **0.000** | **-0.015** | **(0.002)** | **0.000** |
| Marital Status | **0.005** | **(0.001)** | **0.000** | 0.000 | (0.002) | 0.880 |
| Employment Status | 0.002 | (0.002) | 0.335 | -0.006 | (0.004) | 0.096 |
| Education | **0.003** | **(0.001)** | **0.000** | 0.002 | (0.001) | 0.175 |
| Religion | **0.012** | **(0.002)** | **0.000** | **0.006** | **(0.003)** | **0.041** |
| Overall sleep quality | **-0.032** | **(0.001)** | **0.000** | **-0.017** | **(0.002)** | **0.000** |
| GHQ-12 caseness | **-0.090** | **(0.001)** | **0.000** | **-0.081** | **(0.002)** | **0.000** |
| **[_con]** | **3.416** | **(0.007)** | **0.000** | **2.283** | **(0.002)** | **0.000** |
| **γ(SWEMWBS_lagged)** | | | | **0.342** | **(0.008)** | **0.000** |
| **Random part** | | | | | | |
| **SD (Root MSE)** | **0.164** | | | **0.152** | | |

Note: all results in **bold** p<0.05

### 7.4.3 CONSEQUENCES

The second aim of this chapter is to discover the consequences of MWB on ageing well. Ageing well is defined as a state of doing, living and functioning well physically, psychologically and socially. Due to the data available in UKHLS, only limited variables are linked to MWB consequences including: SF-12 (PCS & MCS), physical activities and hospital in-patient days. However, physical activities and hospital in-patient days are only introduced in wave7 (T3). In this case, the SF-12 (PCS & MCS) is used as the measure of the consequences of MWB on ageing well. Since MCS includes similar concepts of MWB which in other words will be highly correlated with MWB, only PCS will be used in the analysis as the measure of physically ageing well. The hypotheses considered in this section are whether older people's MWB has a direct impact on physically ageing well and whether MWB mediates and modifies the effect of other influencing factors on physically ageing well.

#### *7.4.3.1 MWB consequences – physically ageing well (SF-12 PCS)*

The longitudinal association between MWB and PCS was captured by a random-effects model. The hypothesis is that higher MWB will enhance physically ageing well longitudinally even when other covariates have been controlled. In other words, time-lagged MWB (lagged at wave-1) could predict PCS after controlling for demographic & socio-economic variables and psychological variables. The random-effects model excluded general health to avoid multicollinearity since it is highly correlated to PCS. In addition, previous wave's PCS has also been controlled in the lagged response model to investigate the effect of current MWB on PCS at a later time point when adjusting the impact of previous PCS. As displayed in Table 24 below, the result from the random-effects model shows that for each unit increase in the logarithm of MWB, the future logarithm of PCS could increase by 0.086 (SE=0.018, p<0.000) after controlling for demographic & socio-economic and psychological variables including mental illness and sleep quality. MWB and other control variables explain approximately 17.45% of the variance. When taking account of the previous wave's PCS, although the β estimates reduced greatly, a one unit increase in the logarithm of MWB could still increase the future logarithm of PCS by 0.057 (SE=0.015, p<0.000). In addition, including PCS from a previous wave significantly increases the fitness of the model with the later one explaining approximately 50.81% of the variance. The results are statistically significant at the 95% confidence interval.

*Table 24.MWB consequence on physically ageing well, direct effect*

| | Random-effects (L1=wave-1) | | | Lagged response (L1=wave-1) | | |
|---|---|---|---|---|---|---|
| | Est | (SE) | P value | Est | (SE) | P value |
| lnSWEMWBS_L1 | **0.086** | **(0.018)** | **0.000** | **0.057** | **(0.015)** | **0.000** |
| Age_L1 | **-0.028** | **(0.002)** | **0.000** | **-0.016** | **(0.001)** | **0.000** |
| Sex_L1 | -0.004 | (0.007) | 0.514 | -0.003 | (0.005) | 0.541 |
| Financial situation_L1 | **-0.027** | **(0.003)** | **0.000** | **-0.015** | **(0.003)** | **0.000** |
| Marital Status_L1 | **0.020** | **(0.004)** | **0.001** | **0.012** | **(0.004)** | **0.001** |
| Employment Status_L1 | **0.060** | **(0.006)** | **0.000** | **0.025** | **(0.005)** | **0.000** |
| Education_L1 | **0.033** | **(0.003)** | **0.000** | **0.013** | **(0.002)** | **0.000** |
| Religion_L1 | -0.006 | (0.007) | 0.386 | -0.001 | (0.006) | 0.834 |
| Overall sleep quality_L1 | **-0.044** | **(0.004)** | **0.000** | **-0.020** | **(0.003)** | **0.000** |
| GHQ-12 caseness_L1 | **-0.057** | **(0.004)** | **0.000** | **-0.025** | **(0.004)** | **0.000** |
| _cons | **3.573** | **(0.063)** | **0.000** | **1.553** | **(0.062)** | **0.000** |
| **γ (SF-12 PCS_L1)** | | | | **0.549** | **(0.007)** | **0.000** |
| **SD (_con) or ς_u** | **0.2610** | | | **0.1499** | | |
| **SD (residual) or ς_e** | **0.1920** | | | **0.1806** | | |
| **R-sq (overall)** | **0.1745** | | | **0.5081** | | |

Note: all results in **bold** p<0.05

### *7.4.3.2 Mediation effects – Path analysis of MWB*

A mediator mediates the association between independent and dependent variables and explains how such association changes (reduced or no longer exist). The mediation analyses aimed to investigate whether MWB could indirectly enhance ageing well. A mediation model using structural equation modelling (SEM) was therefore conducted to examine whether MWB mediates the association between later-life risk factors (with a particular focus on general health) and PCS. The rationale for using self-rated health as the key variable in the mediation analysis was based on the hypothesis that, independent of general health status, MWB remains positively and independently associated with physically ageing well. Moreover, there is a bidirectional association with MWB and general health, where the negative effect of poor health on physically ageing well could be reduced if individuals have optimal MWB. Other later-life risk factors (i.e.

demographic & socio-economic and psychological factors) were adjusted as covariates in the controlled model.

To begin, the longitudinal association between general health (GH), MWB and PCS was conducted by Pearson correlation coefficient using SEM (see Figure 49 below). As expected, GH has a strong and statistically significant negative association with PCS (Pearson correlation coefficient r=-0.29, SE=0.003, P<0.001). A positive r of 0.017 (SE=0.000, P<0.001) between MWB and PCS and a negative r of -0.076 (SE=0.001, P<0.001) between MWB and GH are also confirmed. In the lagged response model, the associations between current timepoint GH, current time point MWB and a later time point PCS are similar to those in the longitudinal model. GH maintain its strong negative association with PCS in a later time point (r=-0.22, P<0.001) while MWB maintain its positive association with PCS in a later time point (r=0.012, P<0.001). The negative association between MWB and GH still holds (r= -0.06, P<0.001). All associations are statistically significant.

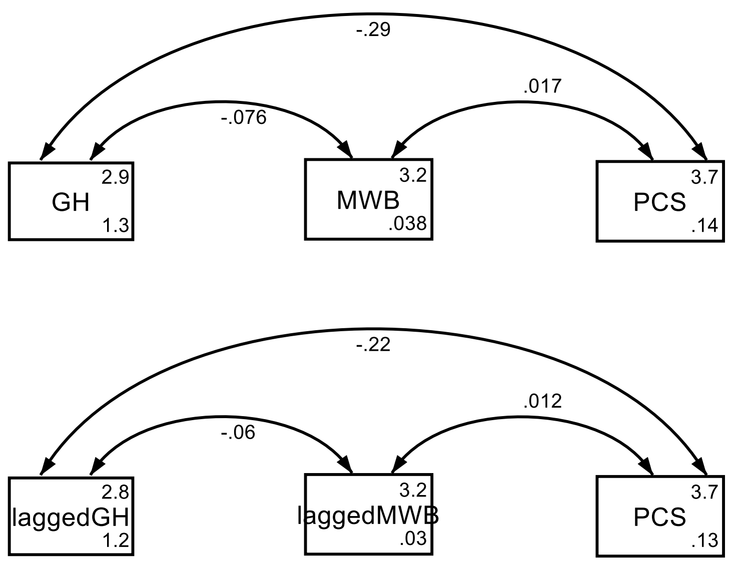



*Figure 49. Pearson correlation coefficient between general health, MWB and SF-12 PCS*

In addition, path analyses were also performed to explain the longitudinal associations. Figure 50 and Table 25 below present the results of path analyses. The overall fitness of the path analyses is 0.4535. Only one path T2MWB → T3PCS is not significant at the 95% confidence interval. Path analysis is also the basis of the mediation model.

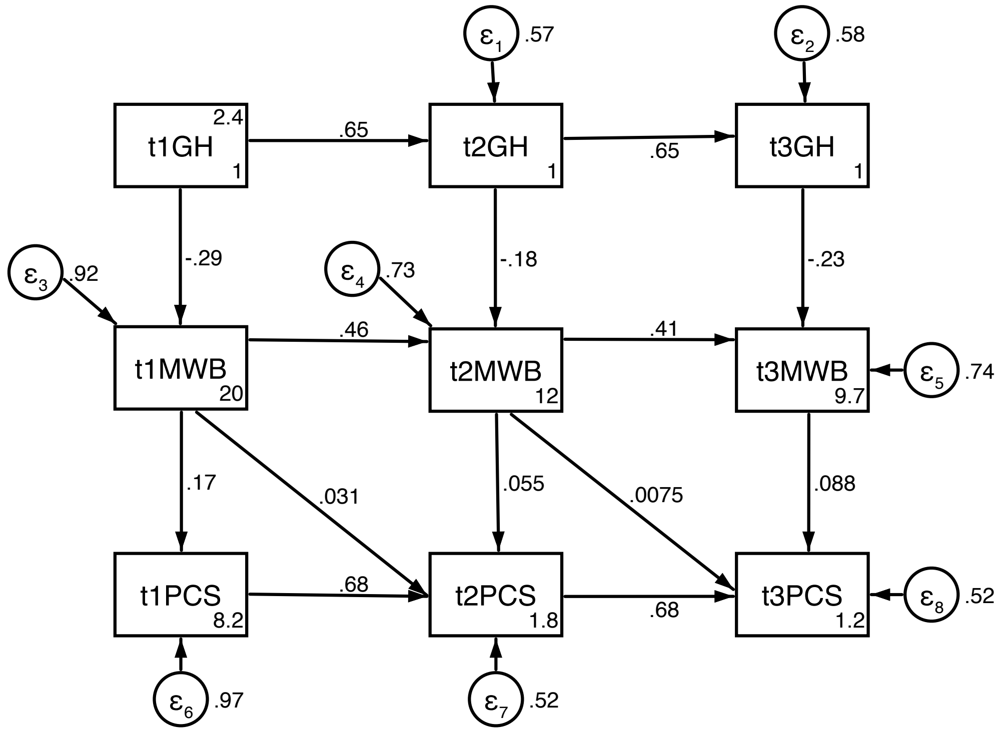



*Figure 50. Path analyses of β estimates by SEM, standardized coefficients are presented*

*Table 25.Statistics of each path (results are summarised from path analyses by SEM)*

| | Statistics for each path (P-value) 95%CI | | | | |
|---|---|---|---|---|---|
| **Path** | **B coef.** | **Z** | **B std. coef.** | **z** | $R^2$ |
| T1GH → T2GH | **0.64 (0.000)** | **54.26** | **0.65 (0.000)** | **80.66** | 0.4252 |
| T2GH → T3GH | **0.63 (0.000)** | **53.42** | **0.65 (0.000)** | **71.35** | 0.4175 |
| T1GH → T1MWB | **-0.04 (0.000)** | **-18.96** | **-0.29 (0.000)** | **-20.22** | 0.0828 |
| T2GH → T2MWB | **-0.03 (0.000)** | **-12.86** | **-0.18 (0.000)** | **-12.95** | 0.2734 |
| T1MWB → T2MWB | **0.44 (0.000)** | **32.80** | **0.46 (0.000)** | **36.38** | |
| T3GH → T3MWB | **-0.04 (0.000)** | **-16.37** | **-0.23 (0.000)** | **-16.56** | 0.2585 |
| T2MWB → T3MWB | **0.48 (0.000)** | **29.19** | **0.41 (0.000)** | **31.44** | |
| T1MWB → T1PCS | **0.33 (0.000)** | **10.56** | **0.17 (0.000)** | **10.71** | 0.0273 |
| T1MWB → T2PCS | **0.06 (0.020)** | **2.32** | **0.03 (0.021)** | **2.30** | 0.4788 |
| T2MWB → T2PCS | **0.12 (0.000)** | **4.19** | **0.06 (0.000)** | **4.17** | |
| T1PCS → T2PCS | **0.68 (0.000)** | **58.11** | **0.68 (0.000)** | **77.86** | |
| T2MWB → T3PCS | 0.02 (0.561) | 0.58 | 0.01 (0.563) | 0.58 | 0.4842 |
| T3MWB → T3PCS | **0.17 (0.000)** | **6.79** | **0.09 (0.000)** | **6.74** | |
| T2PCS → T3PCS | **0.72 (0.000)** | **58.64** | **0.68 (0.000)** | **79.01** | |

Note: all results in **bold** p<0.05

In the mediation model, the dependent variable is PCS while the independent variables are general health (GH) and time-lagged PCS. The mediating variables are MWB and time-lagged MWB. As presented in Table 26 below, there is some evidence of a very small longitudinal mediation effect of MWB between GH and PCS at β=0.001, p<0.001 (β=0.002, p<0.001 after controlling for covariates). The longitudinal mediation effect of MWB between time-lagged PCS and current PCS is slightly larger at β=0.020, p<0.001. However, it lost statistical significance after controlling for covariates. In the path model, similar to the longitudinal model, there is some evidence of a mediation effect between GH and PCS via MWB. Although very small, the effect estimates are all statistically significant in the controlled model. This result indicated that MWB could enhance physically ageing well by reducing the negative impact of poor general health even after controlling other covariates (later life risk factors that including demographic & socio-economic and psychological circumstances). In the cross-lagged association analyses between time-lagged PCS and current PCS through MWB, similar results to the longitudinal model were also performed. The cross waves' mediating estimate was weaker but still suggested a mediation effect of MWB in the uncontrolled model. This result indicated MWB could enhance the positive influence from previous PCS on current PCS.

*Table 26.Results of mediation effects, uncontrolled vs. controlled*

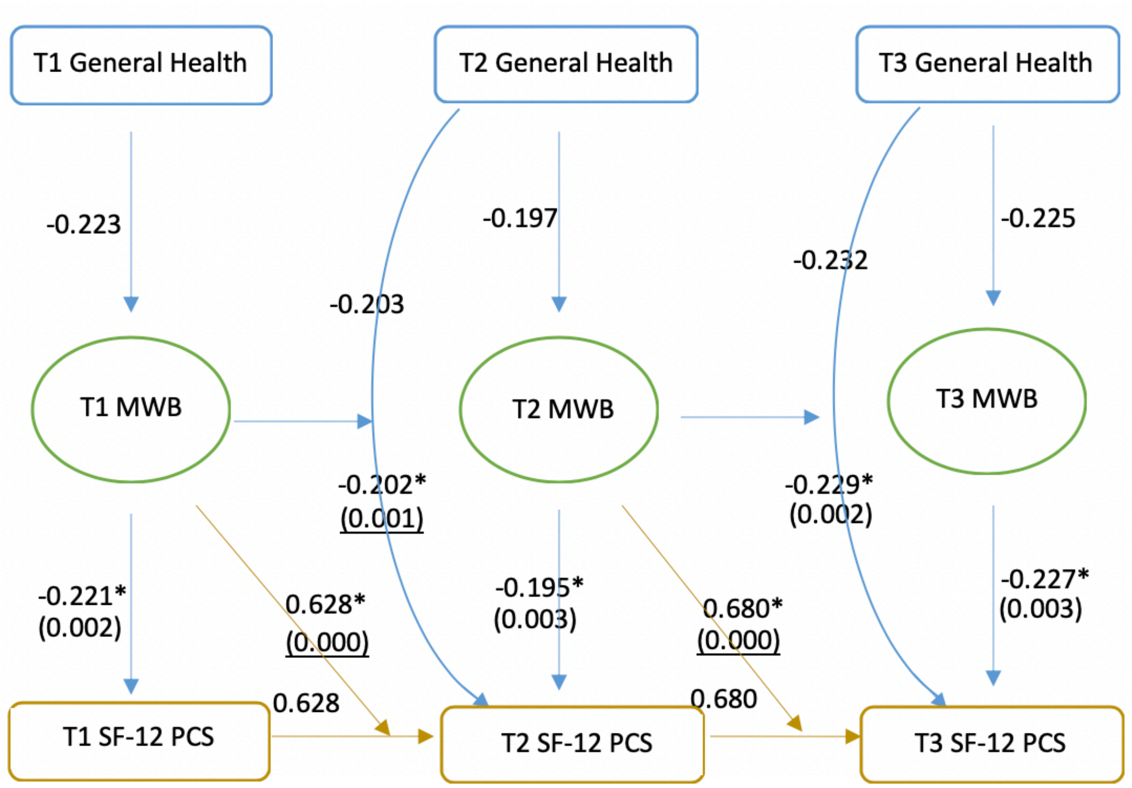
| | Uncontrolled | | Controlled | |
|---|---|---|---|---|
| **Longitudinal model** | **Estimate (SE)** | **P-value** | **Estimate (SE)** | **P-value** |
| **GH → PCS** | | | | |
| **Direct** | **-0.234 (0.001)** | **0.000** | **-0.215 (0.002)** | **0.000** |
| **Indirect (MWB)** | **0.001 (0.000)** | **0.004** | **0.002 (0.000)** | **0.000** |
| **Total** | **-0.232 (0.001)** | **0.000** | **-0.212 (0.002)** | **0.000** |
| **GH → PCS** | | | | |
| **Direct** | **-0.234 (0.002)** | **0.000** | **-0.216 (0.002)** | **0.000** |
| **Indirect (t-1MWB)** | 0.001 (0.000) | 0.103 | **0.001 (0.000)** | **0.000** |
| **Total** | **-0.233 (0.002)** | **0.000** | **-0.215 (0.002)** | **0.000** |
| **t-1PCS → PCS** | | | | |
| **Direct** | **0.695 (0.006)** | **0.000** | **0.627 (0.006)** | **0.000** |
| **Indirect (MWB)** | **0.020 (0.002)** | **0.000** | 0.000 (0.000) | 0.163 |
| **Total** | **0.715 (0.006)** | **0.000** | **0.627 (0.006)** | **0.000** |
| **t-1PCS → PCS** | | | | |
| **Direct** | **0.708 (0.006)** | **0.000** | **0.633 (0.006)** | **0.000** |
| **Indirect (t-1MWB)** | **0.012 (0.001)** | **0.000** | 0.000 (0.000) | 0.582 |
| **Total** | **0.720 (0.006)** | **0.000** | **0.634 (0.006)** | **0.000** |

| | Uncontrolled | | Controlled | |
|---|---|---|---|---|
| **Path model** | **Estimate (SE)** | **P-value** | **Estimate (SE)** | **P-value** |
| **GH → PCS** | | | | |
| **Direct (T1 GH)** | **-0.240 (0.003)** | **0.000** | **-0.223 (0.003)** | **0.000** |
| **Indirect (T1 MWB)** | **0.002 (0.001)** | **0.029** | **0.002 (0.000)** | **0.000** |
| **Total** | **-0.238 (0.002)** | **0.000** | **-0.221 (0.003)** | **0.000** |
| **Direct (T2 GH)** | **-0.219 (0.002)** | **0.000** | **-0.197 (0.003)** | **0.000** |
| **Indirect (T2 MWB)** | 0.001 (0.001) | 0.414 | **0.003 (0.000)** | **0.000** |
| **Total** | **-0.218 (0.002)** | **0.000** | **-0.195 (0.003)** | **0.000** |

| | | | | |
|---|---|---|---|---|
| **Direct (T2 GH)** | **-0.219 (0.003)** | **0.000** | **-0.203 (0.003)** | **0.000** |
| **Indirect (T1 MWB)** | -0.000 (0.001) | 0.725 | **0.001 (0.000)** | **0.001** |
| **Total** | **-0.219 (0.003)** | **0.000** | **-0.202 (0.004)** | **0.000** |
| **Direct (T3 GH)** | **-0.244 (0.002)** | **0.000** | **-0.227 (0.003)** | **0.000** |
| **Indirect (T3 MWB)** | **0.002 (0.001)** | **0.035** | **0.003 (0.000)** | **0.000** |
| **Total** | **-0.242 (0.002)** | **0.000** | **-0.225 (0.003)** | **0.000** |
| **Direct (T3 GH)** | **-0.247 (0.003)** | **0.000** | **-0.232 (0.003)** | **0.000** |
| **Indirect (T2 MWB)** | **0.003 (0.001)** | **0.005** | **0.003 (0.000)** | **0.000** |
| **Total** | **-0.244 (0.003)** | **0.000** | **-0.229 (0.003)** | **0.000** |
| **t-1PCS → PCS** | | | | |
| **Direct (T1 PCS)** | **0.678 (0.010)** | **0.000** | **0.628 (0.010)** | **0.000** |
| **Indirect (T1 MWB)** | **0.011 (0.002)** | **0.000** | 0.000 (0.000) | 0.241 |
| **Total** | **0.690 (0.010)** | **0.000** | **0.611 (0.010)** | **0.000** |
| **Direct (T2 PCS)** | **0.731 (0.009)** | **0.000** | **0.680 (0.009)** | **0.000** |
| **Indirect (T2 MWB)** | **0.013 (0.002)** | **0.000** | 0.000 (0.000) | 0.291 |
| **Total** | **0.744 (0.008)** | **0.000** | **0.680 (0.009)** | **0.000** |

Note: all results in **bold** $p<0.05$, controlled model adjusted for demographic & socio-economic and psychological covariates

Figure 51 below also presents a graphical summary of the mediation effects results from the path model (controlled for demographic & socio-economic and psychological covariates). Each path is presented with the estimated direct effects, total effect (marked with*) and the indirect effect (presented within brackets). Statistical non-significant results (at 95%CI) are underlined.




Note: Each path is presented with the estimated direct effects, total effect* and the indirect effect (). Statistical non-significant (95%CI) results are underlined. Mediation analysis controlled for demographic & socio-economic determinants and psychological covariates.

*Figure 51. Results of mediation effects-path model, controlled only*

### *7.4.3.3 Moderation effects- using dichotomous MWB*

A moderator moderates the association between independent and dependent variables and suggests an interaction or product of independent variable and moderator is significantly associated with the dependent variable. The aim of investigating the moderation effects of MWB was to find out whether previous MWB is a moderator that moderates the association between previous GH and current PCS, and the association between previous PCS and current PCS. The rationale for using self-rated health as the key variable in the moderation analysis is based on the hypotheses that with an optimal level of MWB, older people could achieve physically ageing well, even when their underlined general health is not as good as expected. Moreover, the moderation effect is stronger in those with high

MWB. With the same level of general health, higher MWB will lead to higher physically ageing well. The moderation effects analysis used dichotomous MWB. Instead of the original regression analysis using continuous SWEMWBS and PCS, this section grouped SWEMWBS and PCS by quartiles (see Table 27 below). However, the analysis using dichotomous MWB (compare lower quartile vs upper quartile) would initially reduce the sample size by half.

*Table 27.SWEMWBS & PCS by quartile*

| SWEMWBS | T1 (obs) | Score range | T2 (obs) | Score range | T3 (obs) | Score range |
|---|---|---|---|---|---|---|
| Lower quartile (<=25%) | 2,526 | 7~23 | 3,386 | 7~23 | 3,061 | 7~23 |
| Median (25%-75%) | 4,432 | 23~29 | 3,939 | 23~28 | 4,814 | 23~29 |
| Upper quartile (>=75%) | 2,442 | 29~35 | 3,531 | 28~35 | 3,140 | 29~35 |
| Total | 9,400 | | 10,856 | | 11,015 | |
| Mean (SD) | | 26.01 (4.46) | | 25.48 (4.25) | | 26.11 (4.79) |

| SF-12 PCS | T1 (obs) | Score range | T2 (obs) | Score range | T3 (obs) | Score range |
|---|---|---|---|---|---|---|
| Lower quartile (<=25%) | 3,014 | 4.33~32.47 | 2,737 | 5.68~34.94 | 2,738 | 4.48~35.80 |
| Median (25%-75%) | 6,045 | 32.47~54.26 | 5,489 | 34.94~54.53 | 5,559 | 35.80~54.80 |
| Upper quartile (>=75%) | 3,003 | 54.26~74.46 | 2,719 | 54.53~71.93 | 2,649 | 54.80~71.85 |
| Total | 12,062 | | 10,945 | | 10,946 | |
| Mean (SD) | | 42.66 (13.61) | | 43.76 (12.70) | | 44.26 (12.65) |

A pooled time-lagged multiple regression analysis was initially undertaken to test the moderation effect (see Table 28 below). The results demonstrate that a higher MWB at a previous time point could enhance a higher PCS at a later time point. MWB is a moderator that moderates the association between previous GH and current PCS, and it also moderates the association between previous PCS and current PCS. Moreover, after controlling for covariates (demographic & socio-economic factors), the moderation effects still reach statistical significance, but become much smaller in both associations.

A 92% reduction (reduced from 0.166 to 0.014) is detected on the moderation effects of MWB on the association between previous GH and current PCS. In comparison, a 75% reduction (reduced from 0.166 to 0.041) is detected on the moderation effects of MWB on the association between previous PCS and current PCS. Nonetheless, the initial model estimates that the impact of previous MWB could only explain 5.02% ($p<0.001$) of the variability in current PCS whereas previous GH and previous PCS dominate the effects and explain 30.52% ($p<0.001$) and 48.66% ($p<0.001$) of the variability of future PCS separately. Despite this, the moderation effects of MWB is significant and suggests that with the previous level of general health or physically ageing well controlled, a higher MWB will lead to a higher PCS at a later time point.

*Table 28.Moderation effects of MWB on the association between previous GH, previous PCS and current PCS*

| | | | | coef (SE) 95%CI, lag = T-1 |
|---|---|---|---|---|
| | **T-1~T** | **T-1~T** | **T-1~T** | **T-1~T** |
| **R-squared (Adj. R-sq)** | **5.02% (5.01%)** | **30.52% (30.52%)** | **31.53% (31.52%)** | **35.03% (34.96%)** |
| **MWB (T-1)** | **0.166 (0.008)** | | **0.021 (0.007)** | **0.014 (0.007) *** |
| **GH (T-1)** | | **-0.180 (0.002)** | **-0.177 (0.003)** | **-0.164 (0.003)** |
| **Age (T-1)**<br>60-62 (ref) | | | | **-0.023 (0.002)** |
| **Sex**<br>Male (ref) | | | | **-0.034 (0.007)** |
| **Financial situation (T-1)**<br>Living comfortably (ref) | | | | **-0.019 (0.004)** |
| **Marital status (T-1)**<br>Widowed (ref) | | | | **0.007 (0.005)** |
| **Employment status (T-1)**<br>Unemployed (ref) | | | | **0.046 (0.008)** |
| **Education**<br>No qualification (ref) | | | | **0.010 (0.003)** |
| **Religion**<br>No (ref) | | | | **-0.014 (0.007) *** |

Note: all results in **bold** p<0.05, p-value in **bold** * p<0.1

| | | | | coef (SE) 95%CI, lag = T-1 |
|---|---|---|---|---|
| | **T-1~T** | **T-1~T** | **T-1~T** | **T-1~T** |

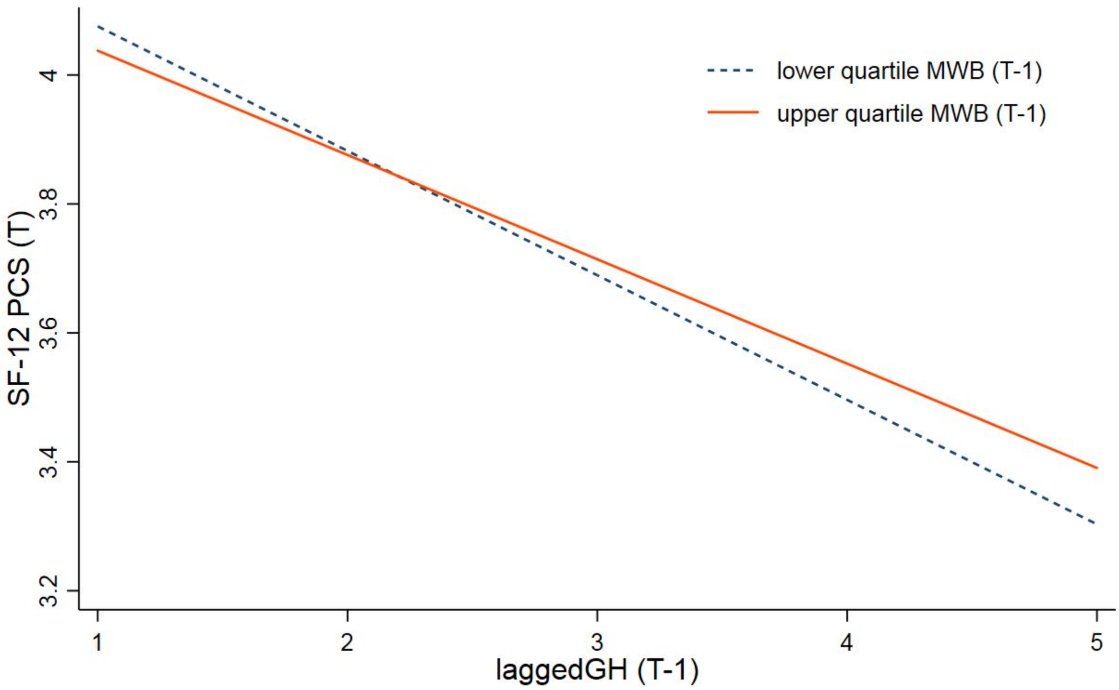
| | | | | |
|---|---|---|---|---|
| **R-squared (Adj. R-sq)** | **5.02% (5.01%)** | **48.66% (48.66%)** | **51.51% (51.50%)** | **52.71% (52.65%)** |
| **MWB (T-1)** | **0.166 (0.008)** | | **0.049 (0.006)** | **0.041 (0.006)** |
| **PCS (T-1)** | | **0.714 (0.006)** | **0.722 (0.008)** | **0.688 (0.007)** |
| **Age (T-1)**<br>60-62 (ref) | | | | **-0.013 (0.001)** |
| **Sex**<br>Male (ref) | | | | -0.006 (0.006) |
| **Financial situation (T-1)**<br>Living comfortably (ref) | | | | **-0.017 (0.003)** |
| **Marital status (T-1)**<br>Widowed (ref) | | | | **0.009 (0.004)** |
| **Employment status (T-1)**<br>Unemployed (ref) | | | | **0.024 (0.006)** |
| **Education**<br>No qualification (ref) | | | | **0.008 (0.003)** |
| **Religion**<br>No (ref) | | | | -0.005 (0.006) |

Note: all results in **bold** $p<0.05$

The moderation effects of MWB on the association between previous GH and current PCS, and between previous PCS and current PCS are also presented graphically in Figure 52 below. The slope differences between the lower quartile MWB and the upper quartile MWB group suggest that different levels of MWB moderate these association differently. The higher MWB is, the more it moderates the association.

In the previous GH – current PCS association, compared to a steeper negative MWB curve (lower quartile MWB), a flatter negative MWB curve (upper quartile MWB) indicates a weaker negative association between previous GH and current PCS that is moderated by MWB. In other words, MWB could reduce the negative impact of previous GH on current PCS.

On the other hand, in the previous PCS - current PCS association, compared to a flatter positive MWB curve (lower quartile MWB), a steeper positive MWB curve (upper quartile MWB) indicates a stronger positive association between previous PCS and current PCS that is moderated by MWB. However, the moderation effects of MWB is much stronger in lower quartile PCS and median PCS groups but relatively small in the upper quartile PCS group (also see Figure 52 below).



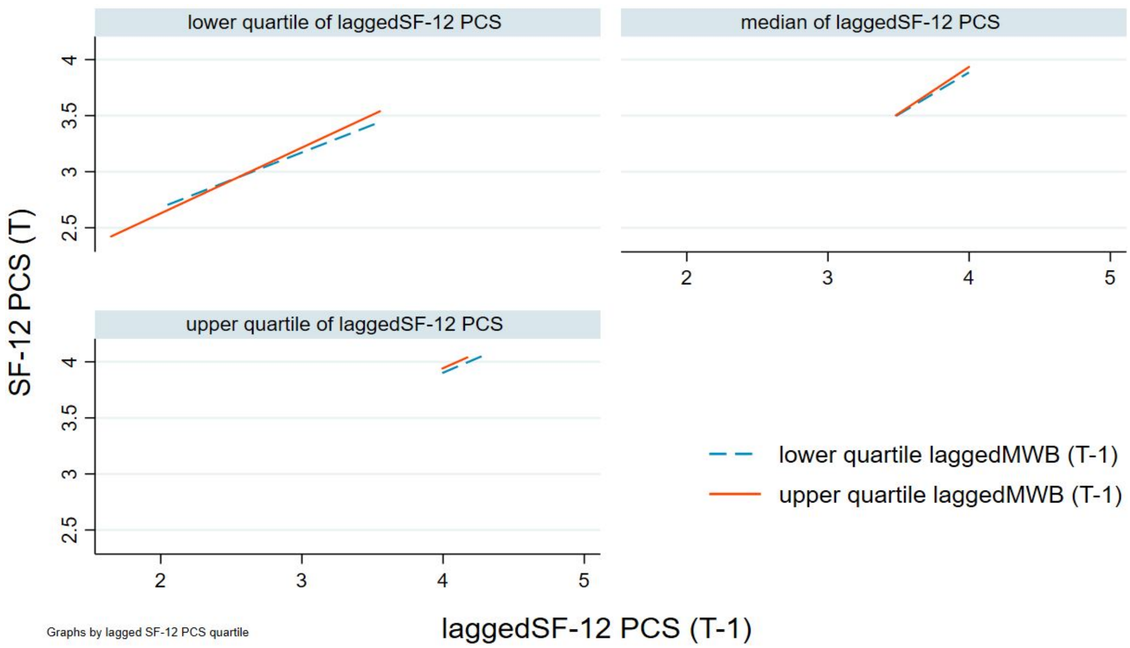




*Figure 52. Moderation effects of MWB on SF-12 PCS-by quartiles*

Logistic regression was also used to investigate whether previous MWB could moderate the association between previous GH, previous PCS and current PCS, adjusted for demographic & socio-economic factors. The hypothesis is that higher previous MWB could reduce the negative impact of low previous GH and low previous PCS on current PCS. Results confirmed the hypothesis that MWB moderates the association. The β estimates of the association between previous poor general health and current PCS is smaller in the upper quartile MWB group (coef=-6.28, SE=0.613, P<0.001) than the lower quartile MWB group (coef=-7.08, SE=0.602, P<0.001). The higher MWB is, the more it moderates the association between a previous time point low level of GH and a later timepoint high level of PCS. The odds ratio for poor GH predicting higher PCS is also significantly doubled in the upper quartile MWB group (OR=0.0018, SE=0.001, P<0.001) than the lower quartile MWB group (OR=0.0008, SE=0.001, P<0.001) (see Table 29 below). With the same (low) level of previous GH individuals who had higher MWB also had a significantly higher probability of achieving a higher PCS at a later time point. In comparison, the β estimates of the association between previous low PCS and current PCS were also higher in the upper quartile MWB group (coef=-6.53, SE=0.342, P<0.001) than the lower quartile MWB group (coef=-6.77, SE=0.379, P<0.001). The odds ratio for lower PCS predicting higher PCS is also significantly higher in the upper quartile MWB group. With the same low level of previous PCS individuals who had higher MWB had a higher probability of achieving a higher PCS at a later time point.

*Table 29.Moderation effects-robust logistic regression*

| Upper quartile PCS(T) | Lower quartile MWB | | Upper quartile MWB | |
|---|---|---|---|---|
| | **Coef. (SE)** | **Odds Ratio (SE)** | **Coef. (SE)** | **Odds Ratio (SE)** |
| **Lagged poor GH (T-1)** | **-7.080 (0.602)** | **0.0008 (0.001)** | **-6.277 (0.613)** | **0.0018 (0.001)** |
| **Lagged lower quartile PCS(t-1)** | **-6.771 (0.379)** | **0.0011 (0.000)** | **-6.532 (0.342)** | **0.0015 (0.000)** |

Note: 95% CI, p<0.0001, adjusted for demographic & socio-economic factors

## 7.5 LOST TO FOLLOW-UP

A Cox proportional hazards regression and a Kaplan-Meier survival curve were undertaken to investigate the lost to follow-up. The analysis was separated into wave-based and interview year-based survival time setting. The lost to follow-up analysis also used dichotomous MWB by comparing lower quartile, median and upper quartile of MWB.

The Kaplan-Meier curve estimation and Kaplan-Meier curve were first examined. The results were in line with the hypothesis that the higher the MWB quartiles, the higher the possibility that older people remained in the follow-up (see Appendix C. Secondary Analyses – 4. Lost to follow-up analysis – 4.1 & 4.2). A log-rank test also provides significant evidence that the survival distributions among MWB quartiles are different.

The results from the Cox proportional hazards model confirmed that higher MWB (quartile) was significantly associated with follow-up (hazard ratio (HR): upper quartile 0.71; median 0.78, lower quartile group had the reference HR=1). The effects were stronger at the interview year-based survival time setting than the wave-based (see Appendix C. Secondary Analyses – 4. Lost to follow-up analysis – 4.3 Cox regression MWB on survival by waves and by years).

The results from the full estimation model also confirmed that higher MWB (quartile) remained significant on reducing the HR of lost to follow-up by at least 10% in both survival time settings (see Appendix C. Secondary Analyses – 4. Lost to follow-up analysis – 4.3 Cox regression MWB on survival by waves and by years) even after controlling for all other influencing factors. Besides, higher education levels were also significantly associated with reducing the HR of lost to follow-up. The key factors associated with increasing lost to follow-up were worse health and advanced age. Compared to excellent self-assessed general health (reference HR=1), fair and poor self-assessed general health could increase the hazard from 1 to 1.3 and 1.6. Starting around age 70, older people presented a significantly increasing hazard on lost to follow-up, with the two oldest-old age groups presenting about two times the hazard compared to reference age 60-62. Poor subjective financial situation was not consistently and significantly associated with the hazard of lost to follow-up. Moreover, chronic conditions (response bias), sex, marital status, employment status, religion, overall sleep quality and mental illness (GHQ-12) did not present any significant association with the hazard of lost to follow-up.

## 7.6 DISCUSSION

This chapter aimed to provide integrated quantitative evidence about the distribution, determinants and consequences of MWB in old age using UKHLS 2009-2017 datasets (3 waves, 9-years follow-up). The findings on MWB distribution in old age were similar to those found in Chapter 6 and provided additional evidence from regressions that including control variables. In line with the results from previous studies (Tampubolon, 2015; Mroczek & Spiro, 2005), this PhD also confirmed a slightly inverted 'U-shape' (convex relationship) MWB distribution in old age after controlling for physical health and demographic & socio-economic circumstances. In addition to previous studies, this chapter also provides some evidence on the inverted 'U-shape' in old age even after adjusting psychological effects including mental illness. Although not in the more advanced age groups (aged 77+), the association between older age and MWB still displayed a slightly inverted 'U-shape' (convex relationship) between age 60 and 77.

The estimated model of MWB was generated. The cross-sectional analysis provided a statistical overview of the determinants of older people's MWB with multiple regression analysis examined the independent predictive ability of categorical determinants in the estimated MWB model. Mental illness was found to be the most influential factor among all other associations with older people's MWB, while physical health was the second most influential factor. This result confirmed the findings from a previous systematic review (Chapter 4) that physical health and mental illness were the dominant factors associated with MWB. It also in line with the results of a number of gerontological studies (Ju et al., 2016; Park, 2014; Kadowaki et al., 2015) and demonstrated statistically significant negative association between mental illness, general (poor) health, (poor) financial situation and MWB, and a statistically significant positive association between having higher qualifications, being retired or in paid employment, being religious and MWB. In addition, the longitudinal analysis also tested this estimated MWB model over time. The results from the mixed-effects (Hausman-Taylor) model confirmed the findings from the cross-sectional analysis, that ill-health (both physically and mentally) and poor financial situation were all significantly associated with low MWB in the long term. On the other hand, being married, being retired or in paid employment, being female, having a higher qualification level and being religious were all significantly associated with high MWB. Nonetheless, this result differs from Momtaz et al., (2016), Ng et al. (2017) and Tajvar et al. (2008) who all suggested similar results with the exception of female gender, which was negatively associated with older people's MWB.

The analysis of MWB consequences suggested that MWB could enhance physically ageing well longitudinally even after controlling for demographic & socio-economic variables and psychological variables. Moreover, what is new to the current knowledge of MWB is that it could mediate and moderate the association between later life risk factors (particularly physical health) and ageing well (physically ageing well). The results from this study provided statistically significant evidence of a small mediation effect of MWB on the association between previous general health and current PCS, and on the association between previous PCS and current PCS. In other words, having MWB could enhance physically ageing well by reducing the negative impact of poor general health and low previous PCS. The results from this study also provided statistically significant evidence of a small moderation effect of MWB on the association between previous general health and current PCS, and on the association between previous PCS and current PCS. Put differently, the higher the MWB, the more it moderates the association. Moreover, when comparing older people with the same level of previous PCS and general health, those having higher MWB at one point in time had higher PCS at a later point in time.

The research undertaken in this chapter has some limitations due to the availability of data from the UKHLS. Firstly, the analysis undertaken in this chapter did not take account of the impact of chronic conditions due to the response bias in the survey datasets. Previously, numerous studies (Kahana et al., 2013; Momtaz et al., 2016; Zimmer & Lin, 1996) had demonstrated a negative association between chronic conditions and older people's MWB. Secondly, there might be missing determinants that also impact on older people's MWB including activities/instrumental activities of daily living (ADLs/IADLs) (Chiao et al., 2012; Chao, 2012; Ng et al., 2017), physical activities (de Souto Barreto, 2014; Fox et al., 2007; Stathi, A., et al., 2002; Vagetti et al., 2015) and cognitive functioning (Banjare et al., 2015). Finally, the analysis of MWB on older people might suffer from attrition bias such that the healthy survivors with higher MWB are more likely to live longer. Hence a lost to follow-up analysis was undertaken in this chapter. The result demonstrated that higher MWB significantly reduced the probability of lost follow-up after controlling for physical health, socio-demographic circumstances and mental illness. Moreover, with the increase in old age, the likelihood of lost follow-up also increased. Despite these limitations, this chapter provided integrated quantitative evidence that links the distribution, determinants and consequences of MWB together and identified and quantified the model of MWB in old age.

# CHAPTER 8 DISCUSSION & CONCLUSION

## 8.1. INTRODUCTION

In this chapter, I integrate and discuss the findings of this PhD thesis. Firstly, the research findings are integrated, summarised and discussed in terms of study aims and objectives and compared with existing literature about mental well-being (MWB) in old age. Secondly, I focus on the methodology of this thesis, including its strengths and limitations. Finally, I discuss the contribution of this PhD in terms of policy implications. The interest in future research is also outlined.

This thesis drew on the central question of the epidemiology of MWB in older people, from its distribution to its determinants and consequences. The overall aim was to discover whether MWB makes any difference to the process of ageing well. A summary of previous chapters is outlined below.

Chapter 1 provided an overview of the structure of this PhD thesis.

Chapter 2 provided the theoretical background of ageing and MWB. The paradox of ageing and MWB and the research background were discussed.

Chapter 3 set out the overall aims and objectives, justified the research questions, generated the research hypotheses and outlined the research gap and overall rationale for this PhD thesis. The measurements of MWB and ageing well were also validated and discussed. Methodologies undertaken in this thesis were detailed, and an overview of the research strategy was provided.

Chapter 4 presented the results of a systematic review of existing literature on the factors related to MWB in old age. Potential aetiological factors were separated into five categories: physical health and functioning; social functioning; behavioural and lifestyle; psychological; and demographic and socio-economic factors.

Chapter 5 presented the results of a systematic review of existing literature on the consequences of MWB in old age. Narrative quantitative analysis was undertaken to examine the MWB consequences of reducing mortality.

Chapter 6 presented the descriptive results of the distribution of MWB using the HSE 7-year datasets. Micro-scoping in on older people's MWB variations in distribution with different age bands was used when analysing older people's MWB.

Chapter 7 presented the results of secondary data analysis of the determinants and consequences of MWB using UKHLS 9-year datasets. Quantitative analyses were performed by:

1) investigating the association between potential later-life risk factors and older people's MWB. The primary explanatory variables were derived from the systematic review in Chapter 4. Multiple regression analysis and multilevel modelling were conducted to assess the determinants of MWB in old age;

2) exploring MWB consequences on ageing well. Random-effects models were conducted to examine the association between MWB and physically ageing well; and

3) examining the mediation and moderation effects of MWB on the association between late-life risk factors (general health) and ageing well. Structural equation modelling (SEM), multiple regression and logistic regression were conducted to assess the effects of MWB.

A lost to follow-up analysis of UKHLS 9-year datasets was also performed. A Cox proportional hazards regression and a Kaplan-Meier survival curve (K-M curve) were applied.

## 8.2. RESULTS INTEGRATION AND DISCUSSION

The main results and findings from this PhD thesis are summarised from three perspectives: the distribution, determinants and consequences of MWB.

### 8.2.1 DISTRIBUTION OF MWB

The first aim of this PhD research was to describe the distribution of MWB. For the purpose of identifying variations in patterns of MWB and generating testable hypotheses regarding MWB in old age, the investigation was carried out in two steps. First, I described the distribution of MWB in old age comparing approximately 5-year, 3-year and 1-year age bands using the HSE 2010-2014 5-year (cross-sectional) combined dataset. Older people differed more from each other than from younger people (Schaie, 2008). Hence using smaller age bands is more suitable when analysing older people's MWB. Second, I undertook multiple regression analysis to estimate age-MWB associations after adjusting for variables associated with older people's MWB arising from the systematic review in Chapter 4 (i.e. physical health, mental illness and socio-demographic variables).

Overall, MWB across lifespan displayed an 'S-shape' with an inverted 'U-shape' appearing in old age. The highest average level of MWB was found in the late 60s, and the lowest appeared in the late 80s and early 90s. This finding is in line with the recent studies (Mroczek & Spiro, 2005; Tampubolon, 2015) that demonstrated an inverted 'U-shape' MWB distribution after controlling for physical health, and demographic & socio-economic factors. On the contrary, Gwozdz & Sousa-Poza (2010), who did not control physical health in their estimate of the age-life satisfaction association, suggested that the rapid decline in those aged 75+ was primarily due to low levels of self-assessed general health. Gwozdz & Sousa-Poza (2010) drew their conclusion due to the similar inverted 'U-shape' pattern found among age-general health and age-MWB in their study. However, as demonstrated from a previous chapter (chapter 7), higher MWB could reduce the negative impact of poor self-rated general health. Furthermore, Gwozdz & Sousa-Poza (2010) used life satisfaction which measures hedonic well-being and has a stronger association with perceived health.

The results in this PhD thesis differed from previous studies, including those which used smaller age bands. This thesis proposed a possibility that MWB in the oldest-old group displays an increase. When using smaller age bands (i.e. 3-year age bands and 1-year age bands) in the descriptive analysis, an increase in MWB for the oldest-old group (age 94+) was apparent. Despite this, due to data availability, the oldest-old group in the regression analysis was set for those aged 84+. Whether there is an increase in those aged 90+ therefore could not be examined by the regression analysis. Nonetheless, MWB varied substantially among the oldest-old group (aged 90+). As summarised in the Chapter 5 systematic review, MWB is also associated with physical health and (lower) mortality rates. The older the age band, the more people would have been lost from that cohort, and these will disproportionately be people with lower MWB and more mental illness. Smaller age bands analysis might be, in this case, biased by this healthy survivor effect. Secondly, the results from the 5-year, 3-year and 1-year age bands analysis only varied a lot in the oldest-old age group (90+). This variation might occur mainly due to the limited number of older people in those age bands. Hence, whether the variation in the 90+ group was due to individual effect or cohort effect was hard to conclude.

### 8.2.2 DETERMINANTS OF MWB

#### *8.2.2.1 Comparing results from quantitative analysis and systematic review*

The second aim of this PhD research was to investigate the aetiological factors associated with older people's MWB (determinants). In this PhD thesis, both cross-sectional and longitudinal analyses using UKHLS 2009-2017 datasets (9-years, three waves) were undertaken. The primary explanatory variables were derived from Chapter 4 systematic review. In summary, self-rated poor health, mental illness, poor sleep quality and poor financial situation were all significantly associated with low MWB. On the other hand, being retired or remain in paid employment, having a higher education level, being religious, being married and being female were all significantly associated with high MWB.

In this PhD thesis, mental illness was demonstrated to be the most influential factor in older people's MWB. Having mental illness compared with no mental illness was associated with significantly lower MWB ($B=-0.1925$, $P<0.001$) in the cross-sectional setting. In the longitudinal setting, the H-T estimator of mental illness effect on MWB was -0.057 ($P<0.001$). This finding reflects the aspect of a single continuum model of MWB that MWB and mental illness sit at the two extreme ends of the MWB continuum (Stewart-Brown, 2017). Besides, poor sleep quality was also noted to have a significant negative association with MWB. The association between having a low level of psychological health and low MWB was also in line with the findings of previous studies in the systematic review – depression and bad sleep quality were relatively consistently associated with lower MWB in old age (Waddell & Jacobs-Lawson, 2010; Park et al., 2014; Ní Mhaoláin et al., 2012; Li et al., 2012; Ju et al., 2016).

General bad health was shown to be the second most influential factor (just following mental illness). Comparing with excellent health, poor general health was associated with significantly lower MWB (B=-0.1036, P<0.001) in the cross-sectional analyses. In the longitudinal analyses, a similar result was also confirmed. The Hausman-Taylor estimator (H-T estimator) of general health effect on MWB was -0.017 (P<0.001) (see Table 30 above). This negative association between having poor physical health and low MWB was also in line with the findings of previous studies (Chiao et al., 2012; Ju et al., 2016; Zimmer & Lin, 1996; Waddell & Jacobs-Lawson, 2010). Additionally, as summarised from the systematic review, previous studies have also identified chronic disease, functional limitations, frailty and disabilities to be negatively associated with older people's MWB (Chiao, 2012; Kahana, 2013; Silverstein, 2006; Ng, 2017; Greenfield & Marks, 2004, Chao, 2012). However, data from the UKHLS did not include suitable data on functional limitations, frailty and disabilities, which were therefore not included in the estimated MWB model in this thesis. Furthermore, due to the response bias of chronic conditions questions in UKHLS (analysed and explained in Chapter 7), the analysis undertaken also excluded chronic conditions from the global determinants of MWB.

In the reviewed studies (Chapter 4 systematic review), a majority of older people rated financial circumstances as one of the good things that gave their life quality (Gabriel & Bowling, 2004; Bowling & Gabriel, 2007). This positive association between financial status and MWB was consistently and statistically significant over age cohorts (Kobayashi et al., 2015) and for both men and women (Kobayashi et al., 2015; Zimme & Lin, 1996). However, objective indicators such as income are usually significant but may be weakly correlated with MWB (Bowling, 2005a). In contrast, subjective indicators such as better perceived economic status (Ng et al., 2017) or satisfaction with income (Burton-Jeangros & Zimmermann-Sloutskis, 2016) predicted a stronger effect on older people's MWB. In this PhD research, a similar pattern was also recognised. MWB did not have a strong association with the financial situation as measured by income. Perceived financial situation, on the other hand, had a closer positive correlation with MWB, although common method variance could be driving the results when two self-reported items are correlated (Campbell & Fiske, 1959; Cote & Buckley, 1987). In this PhD thesis, the financial situation was measured by asking older people how well they managed financially. Compared with the reference groups, worse financial situation was associated with a significant lower MWB. Finding it quite/very difficult to manage financially (the worst financial situation) compared with living comfortably was associated with significantly lower MWB in both cross-sectional setting (B=-0.0640, P<0.001) and longitudinal setting (H-T estimator=-0.016, P<0.001) (see Table 30 above). In line with the previously reviewed studies (Lowis et al., 2011; Li et al., 2012; Momtaz et al., 2016), this PhD thesis also demonstrated that compared with older people who reported being in an inactive (including unemployed) situation, those retired and those in paid employment all presented significantly higher MWB. Being retired predicted slightly higher MWB than remaining in paid employment.

In this PhD thesis, having a degree or higher qualifications (B=0.0120, P<0.001) compared to no qualification, being married (B=0.0063, P=0.022) compared to being widowed, being female (B=0.0053, P=0.007) and being religious (B=0.0121, P<0.001) were associated with significantly higher MWB in the cross-sectional setting. In the longitudinal setting, a similar result was also confirmed (see Table 30 above). Meanwhile, cross-sectional regression analysis in this PhD thesis, confirmed that the association between older age and MWB displayed a slightly inverted 'U-shape' (convex relationship) after adjusting for physical health and demographic & socio-economic factors. In the longitudinal setting, the statistically non-significant effect of advanced age on MWB also lead to a possibility of non-linear association.

In the reviewed studies, having a higher education level and being religious significantly predicted MWB. When breaking it into more detail, Cooper et al. (2011) compared older people among different age cohorts. They demonstrated that compared with younger people under 60, having qualifications significantly and positively predicted happiness for older people aged 80+, but not significantly so for those aged 60-79. By contrast, being married significantly and positively predicted happiness for older people aged 60-69 and 70-79, but not significant for those aged 80+. Zimmer & Lin (1996) and Kobayashi et al. (2015) demonstrated that being married significantly and positively predicted MWB for men but not for women. Becoming widowed was also mentioned as a negative determinant of older people's MWB (Burns et al., 2015). However, Momtaz et al. (2010) also stated that when taking religiosity into account, the effect of being widowed lost its significance. Meanwhile, the impact of religiosity was found to be stronger on the group holding more traditional values (Jang et al., 2006), and on the oldest cohort (Cooper et al., 2011; Levin et al., 1996).

Nevertheless, being female or being in advanced age were reported to have opposite effects in some other reviewed studies. Being female was only found out to be positively associated with older people's MWB in one study (Kadowaki et al., 2015), while negative associations were found in three others: Momtaz et al. (2016), Ng et al. (2017) and Tajvar et al. (2008). Positive associations between advanced age and MWB were found by Kadowaki et al. (2015), Merz & Consedine (2009), Ní Mhaoláin et al. (2012) and Park et al. (2012), while Aghamolaei et al. (2010), Kahana et al. (2013), Lim et al. (2017) and Momtaz et al. (2010) suggested a negative association. Waddell & Jacobs-Lawson (2010) and Zimmer & Lin (1996) performed separate analyses on men and women and suggested that older age was positively associated with older men's MWB but negatively associated with older women's MWB.

#### *8.2.2.2 Results from systematic review only*

The purpose of the systematic review (chapter 4) was to identify the potential determinants of MWB that could be tested in the quantitative analysis (chapter 7). Due to the data available in the UKHLS, only physical health, psychological factors, and demographic & socio-economic factors were included in the quantitative analysis. The estimated model that proposed in the quantitative analysis explained 28.37% of the variability of MWB, which indicates that other factors are also significantly associated with MWB in old age.

As summarised from Chapter 4, 29/61 (47.54%) reviewed studies demonstrated that having good social functioning was associated with high MWB. In the estimated model of MWB, the association between social functioning and MWB was too small to detect its significance. In contrast to the reviewed studies (Burton-Jeangros & Zimmermann-Sloutskis, 2016; Chao, 2012; Lim et al., 2017; Ng et al., 2017; Gautam et al., 2007; Thanakwang et al., 2012; Greenfield & Marks, 2004; Kahana et al., 2013), neither living status (co-residence vs alone) nor the frequency of contact with family and friends was noticed to be significantly associated with MWB. Providing support to others did not generate significant results either. Nevertheless, UKHLS did not include sufficient information on older people's needs and receipt of care.

Furthermore, in the quantitative analysis in Chapter 7, the association of health behaviour & lifestyle and MWB in old age could not be examined due to the data availability in UKHLS. However, prospective observational studies included in the systematic review (McAuley et al., 2000; Van Hoecke et al., 2014) demonstrated a positive association between regular physical activity (PA) and MWB. 14/61 (22.95%) reviewed studies suggested that PA contributed to a dimension of well-being. Moreover, both volume and frequencies of PA moderate the effect.

### 8.2.3 CONSEQUENCES OF MWB

Before quantitative analysis of secondary data from UKHLS, a systematic review of the consequences of MWB in community-dwelling older people aged 60+ was initially undertaken in Chapter 5. Thirteen prospective studies were included in the review. 11/13 (84.62%) studies demonstrated a protective effect of MWB on mortality risk. Further narrative quantitative analysis of 9/11 studies (13 cohorts) showed that MWB was associated with reduced mortality (combined HR=0.83; 95%CI=0.73-0.92). Besides, 3/13 (23.08%) studies suggested that MWB was associated with reduced risk to functional decline and reduced risk to stroke. The research gap in MWB consequences in old age included going beyond the associations with mortality. Therefore, the third aim of this PhD research was to fill the research gap and explore the importance of maintaining a high level of MWB on ageing well. Since MWB is an indicator of psychological wellness, a more robust analysis that drew on MWB in association with physically ageing well was undertaken in Chapter 7. Physically ageing well was assessed using the 12-item short form health survey (SF-12) physical health composite scores (PCS) in the UKHLS.

The results from quantitative analysis using the UKHLS 9-year dataset demonstrated that MWB could enhance physically ageing well longitudinally even after controlling for demographic & socio-economic and psychological confounders. For each unit increase in the logarithm of MWB, the future logarithm of PCS increased by 0.086 (SE=0.018, $p<0.001$). A previous time point MWB independently explained 4.63% of the total variance in PCS at a later time point. MWB and other control variables explained approximately 17.45% of the total variance in PCS.

Furthermore, the results from the quantitative analysis in Chapter 7 also demonstrated a mediation and a moderation effect of MWB on the association between general (poor) health and physically ageing well (PCS) after controlling other later-life risk factors (i.e. demographic & socio-economic and psychological variables). This PhD thesis detected a statistically significant but minimal mediation effect of MWB – having MWB could enhance PCS by reducing the negative impact of poor general health and low previous PCS. The mediation analysis undertaken used structural equation modelling (SEM). Sexton et al. (2014) undertook a similar method and demonstrated that physical impairment could mediate the effect of chronic disease on positive affect and quality of life (measured by CASP-R12) in old age. The study also detected a statistically significant but small moderation effect of MWB – the higher the MWB, the more it moderates the association between general health and PCS. With the same low level of general (poor) health, individuals with higher MWB has a significantly higher possibility of achieving higher PCS at a later time point.

To sum up, despite the general health circumstances individuals have, MWB always positively and independently associates with physically ageing well. Furthermore, there is a bidirectional association with MWB and general health. Physical health is not only the determinant but also a consequence of MWB. The evidence illustrates, the negative effect of poor health on physically ageing well could be diminished depending on the level of MWB. Older people could still achieve physically ageing well if they have an optimal level of MWB, even when their underlined general health is not as good as desired. Moreover, with the same level of general health, higher MWB predicts higher physically ageing well.

## 8.3. STRENGTHS AND LIMITATIONS

### 8.3.1 STRENGTHS

This PhD research had some strengths that should be highlighted.

*Large UK representative sample*

The study population in this PhD thesis is community-dwelling older people in the UK. A particular strength of this PhD research is the secondary analysis of data from two large UK survey datasets: The Health Survey for England (HSE) 2010-2016 7-years datasets and Understanding Society – the UK Household Longitudinal Study (UKHLS) 2009-2017 9-years datasets. Both surveys are considered to be national representative samples of the whole household population.

*A valid measure of MWB*

Another strength of this PhD thesis is the use of the Warwick Edinburgh Mental Wellbeing Scale (WEMWBS) as the instrument to measure older people's MWB. The WEMWBS is developed from both hedonic and eudaimonic perspectives as an instrument to monitor positive mental well-being in terms of feeling and functioning at a population level. As discussed by the Department of Health (2014), WEMWBS is a validated and appropriate measure of mental well-being. To my knowledge, this PhD thesis is the first study that provides additional empirical evidence of the predictive validity of WEMWBS in a large sample of community-dwelling older people in the UK. Also, the present investigation of the epidemiology of MWB in older people is the first empirical demonstration that links the distribution, determinants and consequences of MWB together and identifies and quantifies the model of MWB in old age.

*Comprehensive quantitative analyses*

A vital strength of this PhD is the use of various analytic methods and statistical models. It adds robustness to the results of the determinants and consequences of MWB in old age. Besides, this thesis provides integrated quantitative evidence drawing on two large UK surveys. Both cross-sectional and longitudinal analyses of the combined datasets are performed. A descriptive analysis was used to provide an overview of MWB distribution in old age and followed by a regression analysis to further examine the proposed MWB distribution pattern by adjusting a set of covariates, including physical health and socio-demographic circumstances. Multiple regression analysis and multilevel modelling were undertaken to assess the determinants of older people's MWB. The association between MWB and its consequences was analysed using a random-effects model. The mediation effect of MWB was analysed using structural equation modelling (SEM) and path analysis, while the moderation effect of MWB was analysed using multiple regression and logistic regression. Both unadjusted and adjusted analysis (adjusting for later-life risk factors) were undertaken. A Cox proportional hazards regression and a Kaplan-Meier survival curve were applied to investigate the lost to follow-ups.

### 8.3.2 LIMITATIONS

This PhD research had some limitations that should also be highlighted.

*Secondary data analysis*

The first limitation of this PhD research is the lack of information on primary data collection in the UKHLS. In addition to the quantitative findings from this PhD thesis, the broader literature had demonstrated that other factors also influence older people's well-being (Chapter 4 systematic review). However, due to the data available in the UKHLS, quantitative analyses undertaken in this PhD thesis (Chapter 7) were only able to map some of the potential determinants. There might be missing determinants that also impact on older people's MWB, including activities/instrumental activities of daily living (ADLs/IADLs), physical activities and cognitive functioning.

Furthermore, the broader literature had also demonstrated that MWB could predict lower mortality (Chapter 5 systematic review). Jones et al. (2013) pointed out that older people lost to follow-up in the UKHLS were more likely to have been lost for reasons related to health, including death, hospitalisation, care home admission and being physically or mentally unable to respond. Nonetheless, analysis on whether MWB could protect older people from these adverse events was not applicable due to insufficient data available on reasons for lost to follow-up in the UKHLS.

*Lost to follow-up in longitudinal analysis*

The second limitation of this PhD research is in regard to the lost to follow-up in the study. Lost to follow-up commonly appears in older people's survey datasets, especially secondary datasets, where minimal information was given and the reason for follow-ups to be missing. In this PhD, potential attrition bias might be found among the "healthy survivors". Older people who repeated during follow-ups are anticipated to have a higher level of MWB than those lost to follow-up. A Cox proportional hazards regression and a Kaplan-Meier survival curve were presented to investigate the lost to follow-ups. The results from the Kaplan-Meier curve estimation and the Cox proportional hazards model were in line with the hypothesis that the higher the MWB, the higher the possibility that older people remained in the follow-up. Additionally, the results from lost to follow-up analysis also demonstrated that the older people who remained in the follow-up were more likely to be physically healthier, younger and better educated. Hence, the results from the quantitative analysis in this PhD thesis might suffer from potential attrition bias and selection bias.

Moreover, the mediation and moderation effects of MWB on the association between general (poor) health and physically ageing well were very limited. Although with a longer follow-up period, the mediation and moderation effect might be more conspicuous, it is hard to achieve due to the trait of the sample population (older people) – the longer the years of follow-up, the higher the lost to follow-up.

*The measure of 'Mental well-being' & 'Ageing well'*

This PhD uses the Warwick Edinburgh Mental Wellbeing Scale (WEMWBS) as the instrument to measure older people's MWB. WEMWBS is not the only measure of MWB; however, it is the most important one. The UK's 'Measuring National Well-being Programme' uses WEMWBS to measure personal well-being in the UK (ONS, 2018). The WEMWBS was developed from both a hedonic and eudaimonic perspective as an instrument to monitor positive mental well-being at a population level (Stewart-Brown, 2017).

Nonetheless, due to the data available in the UKHLS, the consequences of MWB in old age were only examined by physical wellness in the ageing process, which was measured by SF-12 PCS in this PhD thesis. However, whether SF-12 PCS was sufficient to indicate physically ageing well still needs validation. More comprehensive analysis of MWB consequences is needed in future research.

*Co-variance in the quantitative analyses*

The quantitative analyses undertaken in chapter 7 may have been affected by co-variance. To an extent, predictor variables in the analyses may have shared a common dimension and hence variance with some outcome variables. Co-variance is common among studies that focus on the association between physical health, mental illness and MWB. A subjective measure such as self-reported general health is confounded by the levels of MWB since older people who feeling better and functioning better reported fewer health complaints and vice versa (Steptoe et al., 2015). Nonetheless, due to the lack of data in the survey, objective indicators of physical health were not included in the analyses.

Previous studies have shown mental distress and MWB are correlated to various degrees, however, the extent to which they are independent of one another remains in dispute. The aggregate scores of GHQ-12 and WEMWBS are consistently and negatively correlated to a highly significant degree (Wilson et al., 2015; Tennant et al., 2007). This is exacerbated by the fact that some GHQ items also ask about positive mental states (i.e. GHQ-12 comprises 6 positive items and 6 negative items). The distribution of scores on the GHQ-12 in UKHLS is highly skewed, with more than 50% of the respondents scored 0 and less than 30% of the respondents scored 4 and above in baseline. With the intention of reducing the correlation to an acceptable level to include mental illness (GHQ-12) as a predictor variable in the analyses, the analyses undertaken in chapter 7 used the categorical GHQ-12 caseness (GHQ-12=0: no mental illness, GHQ-12 between 1-3: less than optimal mental health, GHQ-12 >= 4: mental distress). Nonetheless, the moderation analysis undertaken in chapter 7 could not control for mental distress. The moderation analysis focused on the significance of the interaction of physical health and MWB in association with the dependent variable SF-12 PCS (i.e. SF-12 PCS = $\rho$*physical health + $\theta$*MWB + $\varepsilon$). Including mental distress in this moderation function would ease the effect of MWB since we do not know whether mental distress, MWB and physical health are actually all intimately connected and part of the same underlying phenomenon, or because of artefact (i.e. through the way that we choose to measure these constructs).

Finally, self-rated general health is also a predictor of SF-12 PCS. To reduce to impact of co-variance, lagged values were introduced in the statistical modelling to mitigate concerns over potential reverse causality between physical health and mental well-being. The assumption is, conditional on the previous level of physical health, MWB is exogenous to PCS (physically ageing well) in a later time point. Despite this, given the design of the analyses, co-variance could not be avoided.

### 8.3.3 CONTRIBUTION TO KNOWLEDGE

The investigation of the epidemiology of MWB in older people presented here is the first empirical demonstration that links the distribution, determinants and consequences of MWB together and identifies and quantifies the model of MWB in old age. This PhD research contributes to the knowledge of MWB in old age from the following perspectives: distribution, determinants and consequences.

*Distribution*

This PhD thesis provides additional evidence to the current knowledge of MWB distribution with results from the unadjusted and adjusted analysis. Unadjusted descriptive analysis of older people's MWB in distribution used small age bands (i.e. 5-year, 3-year and 1-year age bands). The distribution of MWB displayed a slightly inverted 'U-shape' (convex relationship) in old age (60-90). The adjusted analysis using multiple regression confirmed this inverted 'U-shape' age-MWB association after controlling for physical health and socio-demographic factors. Although not replicated by the regression analysis due to data availability, the descriptive analysis of MWB distribution also noticed an increase in MWB in the oldest-old age groups (94+). Benefitting from a comparison of different age bands, more variations in MWB distribution with increased age were also detected. An explanation might be that older people show significant variability in how they cope with ageing, and older people are more different from each other than younger people (Schaie, 2008). An alternative explanation is that there are fewer people in the older age groups, which led to more variability due to this small number. Future research on MWB in old age might consider including a larger international sample of people who are older (i.e. 90+) to validate the results from this PhD. The different findings when using smaller age bands is worthy of further post-hoc exploration.

*Determinants*

This PhD started with the preliminary work of two parallel systematic reviews that inclusively reviewed a large body of the most recent studies on the related factors and consequences of MWB in community-dwelling older people. The reviews informed and supported a future secondary analysis in Chapter 7. A total of 18,078 articles were identified by the search terms, and 14,202 citation titles and abstracts were screened after removing duplicates.

The first review in Chapter 4 (factors related to MWB) included a wide range of different study designs using a mixed-method systematic review approach. While previous reviews of the factors related to MWB in old age were fraught with challenges due to the multifactorial influence on MWB and the different measures of MWB used, the present review combined the findings by categorising the factors to physical health & functioning, social functioning, behavioural & lifestyle, psychological, and demographic & socio-economic factors. The result from the review demonstrated some evidence of cumulative effects of factors associated with MWB.

Secondary analysis in Chapter 7 confirmed this cumulative effect construct – many determinants associated with older people's MWB in a complicated matrix. In summary, ill-health (both physically and mentally), poor sleep quality and poor financial situation were all significantly associated with low MWB. On the contrary, being retired, having a higher education level, being religious, being married and being female were all significantly associated with high MWB. Mental illness was demonstrated to be the most influential factor over all other determinants of older people's MWB, while physical health was the second most influential factor.

Chapter 4 systematic review also shone a light on whether the factors associated with older people's MWB change with old age. Regarding the distribution of MWB in old age – a slightly inverted 'U-shape' (convex relationship) between 60-90 and (a possibility of an increase after 90). Further research on exploring this pattern by investigating differences in factors associated with MWB at different life stages is worthy of consideration. Schaie & Will's (2000) 'stage theory of cognition' (as explained in the 'Stage theories' of psychological well-being in chapter 2) provided theoretical support for exploring the different factors associated with MWB at different life stages. Potential determinants of MWB for older people in their 60s to early 70s (young-old as proposed by Schaie & Will) are leisure activities and social engagement after retirement in combination with physical health, mental health and socio-economic factors regarding income or wealth. Potential determinants of MWB for older people in their mid-70s to early 80s (middle-old) are physical health with the likelihood of increasing fragility, and mental health factors such as loneliness and loss. Potential determinants of MWB for older people in their late 80s and above (oldest-old) are physical health, mental health regarding cognition and expectation, and social factors regarding support and relationship.

*Consequences*

The second review – Chapter 5 (Consequences of MWB) included only prospective studies and performed a systematic review and narrative quantitative analysis on the consequences of MWB. The results from the narrative quantitative analysis demonstrated some evidence that MWB could lead to significant inter-personal differences in longevity. The systematic review on MWB consequences provides comprehensive evidence on MWB in association with reduced risk to mortality, functional decline and stroke in old age.

Secondary analysis of the consequences of MWB (Chapter 7) aimed to fill a research gap and focused on the consequences of MWB in later life beyond associations with mortality. The quantitative analysis considered MWB consequences from the aspects of ageing well physically. The results demonstrated some evidence that MWB could enhance physical ageing well longitudinally and independently from demographic & socio-economic variables alongside psychological circumstances. This PhD thesis also provided evidence on other invisible pillars of MWB in old age. What is new to the current knowledge of MWB is that MWB could mediate and moderate the association between general (poor) health and physically ageing well (PCS) after adjusting later-life risk factors (demographic & socio-economic and psychological circumstances). Despite the fact that the effect is minimal, having high MWB could enhance physically ageing well directly and indirectly by reducing the negative impact of poor general health. Having an optimal level of MWB increases the likelihood of achieving physically ageing well independent of general health status among older people. Future research may consider investigating the mediation and moderation effects of MWB using a longer follow-up period (from retirement until death). With a longer follow-up period, the mediation and moderation effect of MWB on the association between general (bad) health and physically ageing well might be more conspicuous.

## 8.4. POLICY IMPLICATIONS

In line with the findings in this PhD thesis, there are several policy implications.

In this study, physical and mental illness were strongly associated with MWB. Mental illness was demonstrated to be the most influential factor over all other factors associated with older people's MWB. This finding is in line with the recent research that argued positive mental health is the most critical factor of an individual's well-being (Layard et al., 2013). Mental illness, on the other hand, increases the risks of disability and absenteeism, leads to unemployment and low productivity and results in enormous welfare losses in terms of misery and economic waste. In the UK, the total cost of mental illness could account for £44,237 per person per annum (Fujiwara and Dolan, 2014). Nonetheless, the UK government had underestimated the impact and neglected mental health with low priority in resource and funds allocation for many years until recently. Ten years on, increasing government attention has been shifted towards mental health. A cross-government mental health outcomes strategy "No health without mental health" was released in 2011 and designed to strengthen the priority given to mental health.

There are many methods of enhancing MWB for older people. Hooyman & Kiyak (2011) suggested that an increasing number of older people remain employed, healthy, socially involved and integrated. In this PhD thesis, being in a good financial situation, being retired or otherwise remaining in paid employment, having a higher education level, being married and being religious are all significantly associated with high MWB. Besides, there is a growing body of interest in how physical activity (PA) and exercise confer favourable health outcomes, including MWB across the lifespan (Cooper et al., 2014; Fox et al., 2007). Increasing physical activity has been demonstrated to improve the MWB of older people in numerous studies. Prospective observational studies included in Chapter 4 systematic review (McAuley et al., 2000; Van Hoecke et al., 2014) showed a positive association between regular PA and MWB in old age. In order to increase older people's well-being, encouraging physical activities is suggested. This progress could be delivered through community-based exercise programmes, such as walking groups or fitness clubs.

A forward-looking policy for promoting ageing well should aim at early prevention of later-life risks. MWB in this PhD thesis has been found out to have a bidirectional association with physical health. It has also been demonstrated in this PhD thesis that MWB mediates and moderates the association between general (poor) health and physically ageing well (PCS) after controlling for later-life risk factors (demographic & socio-economic and psychological circumstances). Improving MWB as well as the physical well-being of older people is hence a key to ageing well. Having an optimal level of MWB could enhance physically ageing well by diminishing the negative impact of poor general health. Older people who perceived a low level of general health could still have the possibility to achieving ageing well if they have a high level of MWB.

## 8.5. CONCLUSIONS

The overall aim of this PhD was to discover whether mental well-being (MWB) influences outcomes associated with ageing and how it is associated with ageing well. In this PhD thesis, I have described the distribution and identified and quantified a model of MWB in old age. I have also provided new and integrated quantitative evidence of the determinants and consequences of MWB by drawing on two large, UK national representative survey datasets (HSE and UKHLS). To my knowledge, this PhD thesis is the first research that links the distribution, determinants and consequences of MWB.

In this PhD thesis, the distribution of MWB displayed a slightly inverted ‘U-shape’ (convex relationship) in old age (60-90) – consistent in both unadjusted and adjusted analysis (physical health and demographic & socio-economic circumstances). MWB in distribution were also noticed to have another increase in the oldest-old age groups (94+) – only in the unadjusted model. It is perhaps worth noting that with the increase in age, older people showed significant variability in MWB from each other. Future research on MWB in old age may consider using smaller age bands and treating older people differently in research design.

This PhD contributes to the growing body of research on the determinants of MWB in old age and demonstrates a multifactorial association and a cumulative impact. In conclusion, the results of this PhD confirm that physical and mental illness are crucial determinants of older people’s MWB, where poor sleep quality and poor financial situation are also significantly associated with low MWB in old age. On the other hand, being retired or remain employed, being female, being married, having a higher qualification level and being religious are all significantly associated with high MWB.

This PhD also confirmed that retaining good MWB, as well as good physical well-being, are vital ingredients for ageing well. MWB could enhance physically ageing well longitudinally even after controlling for demographic and socio-economic variables, as well as psychological variables. This study adds to the current knowledge base by demonstrating the other invisible pillars of MWB in old age. MWB can mediate and moderate the association between general (poor) health and physically ageing well (PCS) despite the fact that the effect is minimal.

Furthermore, this PhD underlines a critical message that MWB plays both roles as a critical outcome and a determinant of physical wellness. At the heart of the term “mental well-being” lies its original meaning: positive feelings and positive functioning (Stewart-Brown, 2018a, p504). This PhD suggests that mental well-being in old age also calls for in-depth knowledge. Increasing the population’s MWB is a national goal. The UK government launched a ‘Measuring National Well-being Programme' in 2010 to develop ‘accepted and trusted measures' of national well-being (ONS, 2018). It is also used by the HM Treasury in resource allocation decisions (Fujiwara & Campbell, 2011). This PhD thesis shines a light on policy initiatives that continue to engage and involve older people who might not otherwise participate in MWB promotion programmes.

# REFERENCES

ageUK (2016) *Later Life in the United Kingdom*. November 2016, ageUK

ageUK (2019) *Briefing: Health and Care of Older People in England 2019*, ageUK

Aghamolaei, T., Tavafian, S. S., & Zare, S. (2010) Health related quality of life in elderly people living in Bandar Abbas, Iran: a population-based study. *Acta Medica Iranica*: 185-191.

Allen, J. (2008) *Older People and Wellbeing*. The Institute for Public Policy Research (IPPR)

Allen, K. (2014), *Gross national happiness - can we measure a UK feelgood factor?* Economic growth (GDP), The Guardian, Available from: https://www.theguardian.com/business/2014/oct/28/gross-national-happiness-can-we-measure-a-uk-feelgood-factor, Tue 28 Oct 2014 11.41 GMT, (Accessed 26 August 2019)

Allerhand, M., Gale, C. R., & Deary, I. J. (2014) The dynamic relationship between cognitive function and positive well-being in older people: a prospective study using the English Longitudinal Study of Aging. *Psychology and aging*, 29(2): 306–318. doi:10.1037/a0036551

Alpass, F., Neville, S., & Flett, R. (2000) Contribution of retirement-related variables to well-being in an older male sample. *New Zealand Journal of Psychology*, 29(2): 74-79.

Andrew, M. K., Fisk, J. D., & Rockwood, K. (2012) Psychological well-being in relation to frailty: a frailty identity crisis?. *International Psychogeriatrics*, 24(8): 1347-1353. doi:10.1017/S1041610212000269

Balaswamy, S., & Richardson, V. E. (2001) The cumulative effects of life event, personal and social resources on subjective well-being of elderly widowers. *The International Journal of Aging and Human Development*, 53(4): 311-327.

Baltes, P. B. & Baltes, M. M. (1990) Psychological perspectives on successful aging: the model of selective optimization with compensation. In: Baltes, P. B. & Baltes, M. M. (eds.) *Successful aging: Perspectives from the behavioral sciences*. Cambridge University Press. New York: 1–34.

Baltes, B. B., Rudolph, C. W., & Bal, A. C. (2012) A review of aging theories and modern work perspectives. In: Hedge J. W. & Borman W. C. (eds.) *Oxford Handbook of Work and Aging*. Oxford University Press. New York, NY: 117-136.

Baltagi, B. H., Bresson, G., & Pirotte, A. (2003) Fixed effects, random effects or Hausman-Taylor? A pretest estimator. *Economics Letters*, 79(3): 361-369. https://doi.org/10.1016/S0165-1765(03)00007-7

Banerjee, S. (1993) Prevalence and recognition rates of psychiatric disorder in the elderly clients of a community care service. *International Journal of Geriatric Psychiatry*, 8(2): 125-131.

Banjare, P., Dwivedi, R., & Pradhan, J. (2015) Factors associated with the life satisfaction amongst the rural elderly in Odisha, India. *Health and quality of life outcomes*, 13(201) doi:10.1186/s12955-015-0398-y

Baron, R. M. & Kenny, D. A. (1986) The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. *Journal of Personality and Social Psychology*, 51(6): 1173-1182. DOI: 10.1037/0022-3514.51.6.1173

Barry, M. & Friedli, L. (2008) *The influence of social, demographic and physical factors on positive mental health in children, adults and older people*, Foresight Mental Capital and Wellbeing Project, State-of-Science Review: SR-B3, Government Office of Science and Innovation, London, UK, http://hdl.handle.net/10379/2684

Bauer, J. M., Levin, V., Munoz Boudet, A. M., Nie, P., & Sousa-Poza, A. (2017) Subjective Well-being Across the Lifespan in Europe and Central Asia. *Journal of Population Ageing*, 10(2): 125–158. https://doi.org/10.1007/s12062-016-9148-0

Baum, C. F. (2016) *An Introduction to Stata Programming (2nd Edition)*, Stata Press, College Station

Bech, P., Olsen, L. R., Kjoller, M., & Rasmussen, N. K. (2003), Measuring well-being rather than the absence of distress symptoms: a comparison of the SF-36 Mental Health subscale and the WHO-Five well-being scale, *International Journal of Methods in Psychiatric Research*, 12(2): 85–91. DOI: 10.1002/mpr.145

Bellis, M. A., Lowey, H., Hughes, K., Deacon, L., Stansfield, J., & Perkins, C. (2012) Variations in risk and protective factors for life satisfaction and mental wellbeing with deprivation: a cross-sectional study. *BMC public health*, 12(492): 1-17. doi:10.1186/1471-2458-12-492

Bilotta, C., Bowling, A., Casè, A., Nicolini, P., Mauri, S., Castelli, M., & Vergani, C. (2010) Dimensions and correlates of quality of life according to frailty status: a cross-sectional study on community-dwelling older adults referred to an outpatient geriatric service in Italy. *Health and quality of life outcomes*, 8(1): 56.

Blanchflower, D. G. & Oswald, A. J. (2004) Well-being over time in Britain and the USA. *Journal of Public Economics*, 88(7-8): 1359–1386.

Blanchflower, D. G. & Oswald, A. J. (2008) Is well-being U-shaped over the life cycle?. *Social Science & Medicine*, 66(8): 1733–1749.

Blazer, D. G., & Hybels, C. F. (2004) What symptoms of depression predict mortality in community‐dwelling elders?. *Journal of the American Geriatrics Society*, 52(12): 2052-2056.

Borenstein, M., Hedges, L. V., Higgins, J. P., & Rothstein, H. R. (2011) *Introduction to meta-analysis*. John Wiley & Sons.

Bosworth, H. B., Schaie, K. W., & Willis, S. L., (1999) Cognitive and sociodemographic risk factors for mortality in the Seattle Longitudinal Study, *The Journal of Gerontology B-Psychology* 54(5): 272-282. https://doi.org/10.1093/geronb/54B.5.P273

Bowling, A. (2005a) Ageing well: Quality of life in old age, *Open University Press*: 176

Bowling, A. (2005b) What Is Successful Ageing and Who Should Define It?, *British Medical Journal* 331 (7531): 1548–51. https://doi.org/10.1136/bmj.331.7531.1548.

Bowling, A. (2007) Aspirations for Older Age in the 21st Century: What Is Successful Aging? *The International Journal of Aging and Human Development* 64 (3): 263–97. https://doi.org/10.2190/L0K1-87W4-9R01-7127.

Bowling, A. (2009) The psychometric properties of the Older People's Quality of Life Questionnaire (OPQOL), compared with the CASP-19, and the WHOQOL-OLD. *Curr Gerontol Geriatr Res* 2009. doi:10.1155/2009/298950

Bowling, A. (2017) *Measuring health: a review of subjective health, well-being and quality of life measurement scales*. London: Open University Press, McGraw-Hill Education, 4th Ed.

Bowling, A. & Gabriel, Z. (2007). Lay theories of quality of life in older age. *Ageing and Society*, 27(6): 827-848.

Bowling, A. & Grundy, E. (2009) Differentials in mortality up to 20 years after baseline interview among older people in East London and Essex. *Age and Ageing*, 38: 51–55. doi: 10.1093/ageing/afn220

Bradburn, N. M. (1969). *The structure of psychological well-being*. Chicago: Walter de Gruyter.

Brodaty, H., Green A. B., & Koschera, A. (2003) Meta-Analysis of Psychosocial Interventions for Caregivers of People with Dementia, *Journal of the American Geriatrics Society*, 51(5): 1–8.

Brown, S. L., Nesse, R. M., Vinokur, A. D., & Smith, D. M. (2003) Providing Social Support May Be More Beneficial Than Receiving It: Results From a Prospective Study of Mortality. *Psychological Science*, 14(4): 320–327. https://doi.org/10.1111/1467-9280.14461

Bryant, L. L., Corbett, K. K., & Kutner, J. S. (2001) In their own words: A model of healthy aging. *Social Science and Medicine*, 53: 927– 941.

Burns, R. A., Byles, J., Mitchell, P., & Anstey, K. J. (2012) Positive components of mental health provide significant protection against likelihood of falling in older women over a 13-year period. *International psychogeriatrics*, 24(9) : 1419-1428.

Burns, R. A., Sargent-Cox, K., Mitchell, P., & Anstey, K. J. (2014) An examination of the effects of intra and inter-individual changes in wellbeing and mental health on self-rated health in a population study of middle and older-aged adults. *Social psychiatry and psychiatric epidemiology*, 49(11): 1849-1858.

Burns, R. A., Browning, C. J., & Kendig, H. L. (2015) Examining the 16-year trajectories of mental health and wellbeing through the transition into widowhood. *International psychogeriatrics*, 27(12): 1979-1986.

Burton-Jeangros, C. & D. Zimmermann-Sloutskis (2016) Life satisfaction trajectories of elderly women living in Switzerland: An age–period–cohort analysis. *Ageing & Society*, 36(1): 106-132.

Campbell, D. T., & Fiske, D. W. (1959) Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological bulletin*, 56(2): 56-81.

Carstensen, L. L., Turan, B., Scheibe, S., Ram, N., Ersner-Hershfield, H., Samanez-Larkin, G. R., Brooks, K. P. & Nesselroade, J. R. (2011) Emotional experience improves with age: evidence based on over 10 years of experience sampling. *Psychology and aging*, 26(1): 21.

CASP (2017). Critical Appraisal Skills Programme (CASP): Making sense of evidence. [Online] Available at: http://www.casp-uk.net/checklists Accessed: Date Accessed.

Chao, S. F. (2012) Functional disability and psychological well-being in later life: Does source of support matter?. *Aging & Mental Health*, 16(2): 236-244.

Chiao, C., Weng, L. J., & Botticello, A. L. (2011) Economic strain and well-being in late life: findings from an 18-year population-based longitudinal study of older Taiwanese adults. *Journal of Public Health*, 34(2): 217-227.

Chida, Y., & Steptoe, A. (2008) Positive psychological well-being and mortality: a quantitative review of prospective observational studies. *Psychosomatic medicine*, 70(7): 741-756. 10.1097/PSY.0b013e31818105ba.

Cimpean D., & Drake R. E. (2011) *Treating co-morbid medical conditions and anxiety/*

*depression*. Epidemiology and Psychiatric Sciences, vol 20, no 2, pp 141–50.

Clark, A. E. (2007) *Born to be mild? Cohort effects don't (fully) explain why well-being is U-shaped in age*. IZA Discussion Papers No. 3170, Institute for the Study of Labor (IZA)

Clegg, A., Young, J., Iliffe, S., Rikkert, M. O., & Rockwood, K. (2013). *Frailty in elderly people*. Lancet (London, England), 381(9868), 752–762. https://doi.org/10.1016/S0140-6736(12)62167-9

Collins, A. L., Goldman, N., & Rodríguez, G. (2008) Is positive well-being protective of mobility limitations among older adults?. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 63(6): 321-327. doi:10.1093/geronb/63.6.p321

Cooper, C., Bebbington, P., King, M., Jenkins, R., Farrell, M., Brugha, T., McManus, S., Stewart, R., & Livingston, G. (2011) Happiness across age groups: Results from the 2007 National Psychiatric Morbidity Survey. *International journal of geriatric psychiatry*, 26: 608-614. 10.1002/gps.2570.

Cooper, R., Stafford, M., Hardy, R., Aihie Sayer, A., Ben-Shlomo, Y., Cooper, C., Craig, L., Deary, I. J., Gallacher, J., McNeill, G., Starr, J. M., Kuh, D., Gale, C. R., & HALCyon study team (2014) Physical capability and subsequent positive mental wellbeing in older people: findings from five HALCyon cohorts. *Age (Dordrecht, Netherlands)*, 36(1): 445-56. doi: 10.1007/s11357-013-9553-8.

Cosco, T. D., Prina, M., Puchalt, J. P., Stephan, B., & Brayne, C. (2013) Operational definitions of successful aging: A systematic review. *International psychogeriatrics,* 26(3): 1-9. DOI:10.1017/S1041610213002287.

Cote J. A. & Buckley M. R. (1987), Estimating Trait, Method, and Error Variance: Generalizing across 70 Construct Validation Studies, *Journal of Marketing Research*, Vol. 24 No. 3, pp. 315-318.

Cresswell-Smith, J., Amaddeo, F., Donisi, V. et al. (2019) *Determinants of multidimensional mental wellbeing in the oldest old: a rapid review*. Soc Psychiatry Psychiatr Epidemiol 54, 135–144 (2019). https://doi.org/10.1007/s00127-018-1633-8

Cross-Government Strategy: Mental Health Division (2009), New horizons: a shared vision for mental health, *London: HM Government*, December 2009 (http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/d h_109708.pdf).

da Silva, V.D., Tribess, S., Meneguci, J. et al. (2019) *Association between frailty and the combination of physical activity level and sedentary behavior in older adults*. BMC Public Health 19, 709. https://doi.org/10.1186/s12889-019-7062-0

De Belvis, A. G., Avolio, M., Sicuro, L., Rosano, A., Latini, E., Damiani, G., & Ricciardi, W. (2008a) Social relationships and HRQL: A cross-sectional survey among older Italian adults. *BMC public health*, 8(1): 348.

De Belvis, A.G., Avolio, M., Spagnolo, A., Damiani, G., Sicuro, L., Cicchetti, A., Ricciardi, W. & Rosano, A. (2008b) Factors associated with health-related quality of life: the role of social relationships among the elderly in an Italian region. *Public health* 122(8): 784-793.

Department of Health (2014) *Wellbeing and Health*. Department of Health, Available from:https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/225525/DH_wellbein g_health.PDF de Souto Barreto, P. (2014) Direct and indirect relationships between physical activity and happiness levels among older adults: a cross-sectional study. *Aging & mental health*, 18(7): 861-868.

Diener, Ed (1984) Subjective Well-Being. *Psychological Bulletin*, 95(3): 542-575. Available at SSRN: https://ssrn.com/abstract=2162125

Diener, E. D., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985) The satisfaction with life scale. *Journal of personality assessment*, 49(1): 71-75.

Diener, E., Wirtz, D., Tov, W., Kim-Prieto, C., Choi. D., Oishi, S., & Biswas-Diener, R. (2009). *New measures of well-being: Flourishing and positive and negative feelings*. Social Indicators Research, 39, 247-266

Diener, E. & Chan, M. Y. (2011) Happy people live longer: subjective well-being contributes to health and longevity. Appl Psychol Health Well Being 2011; 3: 1– 43.

Dionigi, R. (2007) Resistance training and older adults' beliefs about psychological benefits: the importance of self-efficacy and social interaction, *Journal of Sport & Exercise Psychology*, 29: 723-746

Dolan, P. & Metcalfe, R. (2012) Measuring Subjective Wellbeing: Recommendations on Measures for use by National Governments. *Journal of Social Policy*, 41(2): 409-427. doi:10.1017/S0047279411000833

Dolan P. & White M. P. (2007), How can measures of subjective well-being be used to inform public policy?, *Perspectives on Psychological Science*, vol. 2, no. 1, pp: 71–85

Dupuy, H. J. (1984) The psychological General Well-Being (PGWB) index. In: Wenger, N. K., Mattson, M. E., Furberg, C. D., Elinson, J. (eds) *Assessment of the quality of life in clinical trials of cardiovascular therapies*. Lejacq, New York: 170–183

Dychtwald, K. (1999) Age power: How the new-old will transform medicine in the 21st century. *Geriatrics*, 54(12): 22–27.

Easterlin, R. A. (2006) Life cycle happiness and its sources: Intersections of psychology, economics, and demography. *Journal of Economic Psychology*, 27(4): 463-482.

Elliott, J., Gale, C. R., Parsons, S., Kuh, D., & HALCyon Study Team. (2014) Neighbourhood cohesion and mental wellbeing among older adults: A mixed methods approach. *Social science & medicine*, 107: 44-51.

Erikson, E. H. (1982) *The life cycle completed*. New York, NY: Norton

Erikson, E. H. (1998) *The Life Cycle Completed: Extended Version with New Chapters on the Ninth Stage of Development by Joan M. Erikson*. London: W.W. Norton

Featherstone, H. & Whitham, L. (2010) *Careless: Funding long-term care for the elderly*. London, Policy Exchange.

Fengler, A. P., Danigelis, N. L., & Grams, A. (1982) Marital status and life satisfaction among the elderly. *International Journal of Sociology of the Family*: 63–76.

Fernández-Ballesteros, R., Garcia, L. F., Abarca, D., Blanc, E., Efklides, A., Moraitou, D., & Kornfeld, R. (2009) The Concept of 'Ageing Well' in Ten Latin American and European Countries. *Ageing and Society,* 30 (01): 41–56. https://doi.org/10.1017/S0144686X09008587.

Fillit, H. M., Butler, R. N., O'Connell, A. W., Albert, M. S., Birren, J. E., Cotman, C. W., Greenough, W. T., Gold, P. E., Kramer, A. F., Kuller, L. H., Perls, T. T., Sahagan, B. G., & Tully, T. (2002) Achieving and maintaining cognitive vitality with aging, *Mayo Clinic Proceedings*, 77(7): 681–696

Fischer, J. V. A. (2009) *Happiness and age cycles-return to start...? On the functional relationship between subjective well-being and age*. OECD Social, Employment and Migration Paper No. 99: OECD Publishing, DOI: http://dx.doi.org/10.1787/220573570724

Fisher, K. J., & Li, F. (2004) A community-based walking trial to improve neighborhood quality of life in older adults: a multilevel analysis. *Annals of Behavioral Medicine*, 28(3): 186-194. DOI: 10.1207/s15324796abm2803_7

Fox, K., Stathi, A., McKenna, J., & Davis, M. (2007) Physical activity and mental well-being in older people participating in Better Ageing Project. *European journal of applied physiology*, 100: 591-602. 10.1007/s00421-007-0392-0.

Frazier, C., Mintz, L. B., & Mobley, M. (2005) A Multidimensional Look at Religious Involvement and Psychological Well-Being Among Urban Elderly African Americans. *Journal of Counseling Psychology*, 52(4): 583-590.

Freund A. M. & Baltes P. B. (2002), Life-management strategies of selection, optimization and compensation: Measurement by self-report and construct validity. *Journal of personality and social psychology*, 82: 642-662. DOI: 10.1037//0022-3514.82.4.642.

Fried L. P., Tangen C. M., Walston J., et al. (2001) *Frailty in older adults: evidence for a phenotype*. J Gerontol A Biol Sci Med Sci 2001;56:M146–56.

Fried L. P. (2016). *Interventions for Human Frailty: Physical Activity as a Model. Cold Spring Harbor perspectives in medicine*, 6(6), a025916. https://doi.org/10.1101/cshperspect.a025916

Friedli, L. (2009) *Mental health, resilience and inequalities* (No. EU/08/5087203). Copenhagen: WHO Regional Office for Europe.

Fry C. L. et al (1997) Chapter 5 — Culture and the meaning of a good old age. In: Sokolovsky J, editor. The cultural context of aging — worldwide perspectives. 2nd ed. Westport (CT): Bergin & Garvey; 1997. pp. 99–123

Fujiwara, D. I. & Campbell, R. T. (2011) *Valuation Techniques for Social Cost-Benefit Analysis: Stated Preference, Revealed Preference and Subjective Well-Being Approaches*: *A Discussion of the Current Issues*. Department for Work and Pensions, HM Treasury

Fujiwara, D., & Dolan, P. (2014) Valuing mental health. *Policy*, 4(2.1).

Gabriel, Z., & Bowling, A. (2004) Quality of life from the perspectives of older people. *Ageing & Society*, 24(5): 675-691.

Gale, C. R., Dennison, E. M., Cooper, C., & Sayer, A. A. (2011) Neighbourhood environment and positive mental health in older people: the Hertfordshire Cohort Study. *Health & place*, 17(4): 867-874.

Gale, C. R., Deary, I. J., & Stafford, M. (2013) A life course approach to psychological and social wellbeing. In: Kuh D. et al. (eds.) *A life course approach to healthy ageing,* Oxford University Press, Oxford: 46-62

Gale, C. R., Cooper, C., Sayer, A. A. (2015) *Prevalence of frailty and disability: findings from the English Longitudinal Study of Ageing*, Age and Ageing, Volume 44, Issue 1, January 2015, Pages 162–165, https://doi.org/10.1093/ageing/afu148

Gale, C. R, Mõttus, R., Deary, I. J, Cooper, C., & Sayer, A. A. (2017) Personality and risk of frailty: The English longitudinal study of ageing. *Annals of Behavioral Medicine*, 51(1): 128-136. http://dx.doi.org/10.1007/s12160-016-9833-5

García, E. L., Banegas, J. R., Perez-Regadera, A. G., Cabrera, R. H., & Rodriguez-Artalejo, F. (2005) Social network and health-related quality of life in older adults: a population-based study in Spain. *Quality of life research*, 14(2): 511-520.

Garfein, A. J., & Herzog, A. R. (1995) Robust aging among the young-old, old-old, and oldest-old. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 50(2): S77-S87. https://doi.org/10.1093/geronb/50B.2.S77

Gautam, R., Saito, T., & Kai, I. (2007) Leisure and religious activity participation and mental health: gender analysis of older adults in Nepal. *BMC public health*, 7(1): 299.

Gelman A. & Hill J. (2007) *Data Analysis using Regression and Multilevel/Hierarchical Models*. Cambridge University Press: Cambridge; New York, pp. 60-61

George, L. K. (2010) Still happy after all these years: Research frontiers on subjective well-being in later life. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, 65: 331–339

Glenn, N. (2009) Is the apparent U-shape of well-being over the life course a result of inappropriate use of control variables? A commentary on Blanchflower and Oswald (66: 8, 2008, 1733–1749). *Social science & medicine*, 69(4): 481-485.

Goldberg, D. P., & Williams, P. A user's guide to the GHQ. Windsor, *NFER Nelson*. 1988

Golden, J., Conroy, R. M., & Lawlor, B. A. (2009) Social support network structure in older people: underlying dimensions and association with psychological and physical health. *Psychology, Health & Medicine*, 14(3): 280-290.

Gouveia, É. R. Q., Gouveia, B. R., Ihle, A., Kliegel, M., Maia, J. A., i Badia, S. B., & Freitas, D. L. (2017) Correlates of health-related quality of life in young-old and old–old community-dwelling older adults. *Quality of life research*, 26(6): 1561-1569.

Gow, A. J., Pattie, A., Whiteman, M. C., Whalley, L. J., & Deary, I. J. (2007) Social support and successful aging: Investigating the relationships between lifetime cognitive change and life satisfaction. *Journal of Individual Differences*, 28(3): 103-115.

Greaves, C. J. & Farbus, L. (2006) Effects of creative and social activity on the health and well-being of socially isolated older people: outcomes from a multi-method observational study. *The Journal of the Royal Society for the Promotion of Health*, 126(3): 134-42.

Greenfield, E. A. & Marks, N. F. (2004) Formal volunteering as a protective factor for older adults' psychological well-being. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences*, 59(5): S258-S264.

Grundy, E. & Read, S. (2012) Social contacts and receipt of help among older people in England: are there benefits of having more children? *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 67(6): 742–754, doi:10.1093/geronb/gbs082

Gunasekara, F. I., Richardson, K., Carter, K., & Blakely, T. (2014) Fixed effects analysis of repeated measures data. *International Journal of Epidemiology*, 43(1): 264–269. https://doi.org/10.1093/ije/dyt221

Gurin G., Veroff J., & Feld S. (1960), Americans view their mental health, *New York: Basic Books*

Gwozdz, W. & Sousa-Poza, A. (2010) Ageing, health and life satisfaction for the oldest old: an analysis for Germany. *Social Indicators Research*, 2010: 397-417.

Haight, K. B., Barba, B., Tesh, S. A., Courts, F. N. (2002) Thriving A Life Span Theory. *Journal of gerontological nursing*. 28:14-22. 10.3928/0098-9134-20020301-05.

Hankins, M. (2008) The reliability of the twelve-item general health questionnaire (GHQ-12) under realistic assumptions. *BMC public health*, 8(1): 355. doi:10.1186/1471-2458-8-355.

Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica*, 46(6): 1251–1271.

Hausman, J. A. & Taylor, W. E. (1981) Panel Data and Unobservable Individual Effects. *Econometrica*, 49:1377–1398.

Haver, A. et al. (2015). *Measuring mental well-being: A validation of the Short Warwick–Edinburgh Mental Well-Being Scale in Norwegian and Swedish.* Scandinavian Journal of Public Health. 43. 10.1177/1403494815588862.

Hawkins B. A. (2005). *Aging well: toward a way of life for all people*. Preventing chronic disease, 2(3), A03.

Heckhausen, J., Dixon, R. A., & Baltes, P. B. (1989) Gains and losses in development throughout adulthood as perceived by different adult age groups. *Developmental Psychology*, 25(1): 109-121. DOI: 10.1037/0012-1649.25.1.109

Hellström, Y. & Hallberg, I. R. (2001) Perspectives of elderly people receiving home help on health, care and quality of life. *Health and Social Care in the community*, 9(2): 61–71

Hellström, Y., Magdalena, A., & Ingalill, H. (2004) Quality of life among older people in Sweden receiving help from informal and/or formal helpers at home or in special accommodation. *Health & Social Care in the Community*, 12: 504-516. 10.1111/j.1365-2524.2004.00519.x.

Henry, W. E. & Cumming, E. (1959) Personality Development in Adulthood and Old Age. *Journal of Projective Techniques*, 23(4): 383-390. DOI:10.1080/08853126.1959.10380946

Heo, J., Chun, S., Lee, S., Lee, K. H., & Kim, J. (2015) Internet use and well-being in older adults. *Cyberpsychology, Behavior, and Social Networking*, 18(5): 268-272.

Hernandez, R., Bassett, S. M., Boughton, S. W., Schuette, S. A., Shiu, E. W., & Moskowitz, J. T. (2018). *Psychological Well-Being and Physical Health: Associations, Mechanisms, and Future Directions*. Emotion Review, 10(1), 18–29. https://doi.org/10.1177/1754073917697824

Heun, R., Bonsignore, M., Barkow, K., & Jessen, F. (2001) Validity of the five-item WHO Well-Being Index (WHO-5) in an elderly population. *European archives of psychiatry and clinical neuroscience*, 251(2): 27-31.

Higgs, P., Hyde, M., Arber, S., & Blane, D. (2005) Dimensions of the inequalities in quality of life in older age. In: Walker, A. (eds.) *Understanding quality of life in old age*. *Open University Press*: 27-48.

Higueras‐Fresnillo, S. et al. (2018) *Physical Activity and Association Between Frailty and All‐Cause and Cardiovascular Mortality in Older Adults: Population‐Based Prospective Cohort Study*. J Am Geriatr Soc, 66: 2097-2103. doi:10.1111/jgs.15542

Hirosaki, M., Ishimoto, Y., Kasahara, Y., Konno, A., Kimura, Y., Fukutomi, E., Chen, W., Nakatsuka, M., Fujisawa, M., Sakamoto, R. & Ishine, M. (2013) Positive affect as a predictor of lower risk of functional decline in community‐dwelling elderly in Japan. *Geriatrics & gerontology international*, 13(4): 1051-1058.

Hooyman, N. R. & Kiyak, H. A. (2011) *Social Gerontology: A Multidisciplinary Perspective*, 9th Edition, Pearson

Horn, J. L. (1982) The theory of fluid and crystallized intelligence in relation to concepts of cognitive psychology and aging in adulthood. In: Craik, F. I. M. & Trehub, S. (eds.) *Aging and cognitive processes.* Plenum, New York: 237-278.

Howden-Chapman, P. L., Chandola, T., Stafford, M., & Marmot, M. (2011) The effect of housing on the mental health of older people: the impact of lifetime housing history in Whitehall II. *BMC public health*, 11(682): 1-8. doi:10.1186/1471-2458-11-682

HSCIC (2014) *Focus on the Health and Care of Older People - June 2014*. Health & Social Care Information Center. http://www.hscic.gov.uk/catalogue/PUB14369

Hurst, N. P., Ruta, D. A., & Kind, P. (1998) Comparison of the MOS short form-12 (SF12) health status questionnaire with the SF36 in patients with rheumatoid arthritis. *British journal of rheumatology*, 37(8): 862-869.

Humphrey, A., Lee, L., & Green, R. (2011) Aspirations for later life: A report of research carried out by the National Centre for Social Research on behalf of the Department for Work and Pensions (Research Report No 737).

Huxhold, O., Fiori, K. L., & Windsor, T. D. (2013) The dynamic interplay of social network characteristics, subjective well-being, and health: The costs and benefits of socio-emotional selectivity. *Psychology and Aging*, 28(1): 3-16.

Hyde, M., Wiggins, R. D., Higgs, P., & Blane, D. B. (2003) A measure of quality of life in early old age: the theory, development and properties of a needs satisfaction model (CASP-19). *Aging and Mental Health*, 7(3): 186–194

Ingersoll-Dayton, B., Saengtienchai, C., Kespichayawattana, J., & Aungsuroch, Y. (2001). Psychological well-being Asian style: The perspective of Thai elders. *Journal of Cross-Cultural Gerontology*, 16: 283–302.

Ingersoll-Dayton, B., Saengtienchai, C., Kespichayawattana, J., & Aungsuroch, Y. (2004). Measuring psychological well-being: Insights from Thai elders. *The Gerontologist*, 44: 596–604.

Institute of Medicine (1989) *Quality of Life and Technology Assessment*. Washington, DC: The National Academies Press. https://doi.org/10.17226/1424.

Izard, C.E. (1971) *The face of emotion*. New York: Appleton-Century-Crofts

Jackson, C. (2007) The general health questionnaire. *Occupational medicine*, 57(1): 79-79. https://doi.org/10.1093/occmed/kql169

Jacobs, J. M., Cohen, A., Ein-Mor, E., Maaravi, Y., & Stessman, J. (2011) Frailty, cognitive impairment and mortality among the oldest old. *The journal of nutrition, health & aging*, 15(8) : 678-682. https://doi.org/10.1007/s12603-011-0096-3

Jahoda, M. (1958) *Current concepts of positive mental health*, New York: Basic Books

Jakobsson, U. (2007) Using the 12-item Short Form health survey (SF-12) to measure quality of life among older people. *Aging clinical and experimental research*, 19(6): 457-464. DOI: 10.1007/BF03324731

Jang, Y., Borenstein, A. R., Chiriboga, D. A., Phillips, K., & Mortimer, J. A. (2006) Religiosity, adherence to traditional culture, and psychological well-being among African American elders. *Journal of Applied Gerontology*, 25(5): 343-355.

Jeste, D. V., Depp, C. A., & Vahia, I. V. (2010) Successful cognitive and emotional aging. *World psychiatry: official journal of the World Psychiatric Association (WPA)*, 9(2): 78–84.

John, V. H. (2010) Ageing, neurodegeneration and Parkinson's disease. *Age and Ageing*, 39(2): 156–161. https://doi.org/10.1093/ageing/afp223.

Jones, A. M., Rice, N., d'Uva, T. B., & Balia, S. (2013) *Applied health economics*. second ed. Routledge, Taylor & Francis. p.280

JPND Research (2015), Why choose neurodegenerative diseases? *JPND Research*, Retrieved February 7, 2015

Ju, Y. J., Han, K. T., Lee, T. H., Kim, W., Kim, J., & Park, E. C. (2016) Does relationship satisfaction and financial aid from offspring influence the quality of life of older parents?: a longitudinal study based on findings from the Korean longitudinal study of aging, 2006–2012. *Health and quality of life outcomes*, 14(1): 108.

Kadowaki, L., Wister, A. V., & Chappell, N. L. (2015) Influence of home care on life satisfaction, loneliness, and perceived life stress. *Canadian Journal on Aging/La Revue canadienne du vieillissement*, 34(1): 75-89.

Kahana, E., Bhatta, T., Lovegreen, L. D., Kahana, B., & Midlarsky, E. (2013) Altruism, helping, and volunteering: pathways to well-being in late life. *Journal of aging and health*, 25(1): 159-187.

Keyes, C. L. M. (1998) Social well-being. *Social Psychology Quarterly*, 61: 121–140

Keyes, C. L. M. (2005) *Mental illness and/or mental health? Investigating axioms of the complete state model of health*. Journal of Consulting and Clinical Psychology, 73, 539–548

Keyes, C. L. M. (2006). *Mental health in adolescence: Is America's youth flourishing?* American Journal of Orthopsychiatry, 76, 395–402

Keyes, C. L. M., Wissing, M., Potgieter, J. P., Temane, M., Kruger, A., & van Rooy, S. (2008). *Evaluation of the Mental Health Continuum Short Form (MHC-SF) in Setswana speaking South Africans*. Clinical Psychology and Psychotherapy, 15, 181–192

Keyes, C. L., & Simoes, E. J. (2012). *To flourish or not: positive mental health and all-cause mortality*. American journal of public health, 102(11), 2164–2172. https://doi.org/10.2105/AJPH.2012.300918

Keyes, C. L. M. (2013). *Mental well-being: international contributions to the study of positive mental health*. Dordrecht; New York: Springer, c2013: 5-13

Kim, E. S., Strecher, V. J., & Ryff, C. D. (2014) Purpose in life and use of preventive health care services. *Proceedings of the National Academy of Sciences*, 111(46): 16331-16336. www.pnas.org/cgi/doi/10.1073/pnas.1414826111

Kimm, H., Sull, J. W., Gombojav, B., Yi, S. W., & Ohrr, H. (2012) Life satisfaction and mortality in elderly people: the Kangwha cohort study. *BMC public health*, 12(1): 54. http://www.biomedcentral.com/1471-2458/12/54

Kirchmann, H., Nolte, T., Runkewitz, K., Bayerle, L., Becker, S., Blasczyk, V., Lindloh, J. & Strauss, B. (2013) Associations between adult attachment characteristics, medical burden, and life satisfaction among older primary care patients. *Psychology and aging*, 28(4): 1108.

Kirkwood, T. B. L. (2008) A systematic look at an old problem. *Nature,* 451: 644–647. doi:10.1038/451644a.

Knickman, J. R. & Snell, E. K. (2002) The 2030 Problem: Caring for Aging Baby Boomers. *Health Services Research*, 37: 849-884. doi:10.1034/j.1600-0560.2002.56.x

Knott, C. (2012). *General mental and physical health*. Health survey for England, 1. http://healthsurvey.hscic.gov.uk/media/1024/chpt-4-gen-physical-and-mental-health.pdf

Kobayashi, E., Liang, J., Sugawara, I., Fukaya, T., Shinkai, S., & Akiyama, H. (2015) Associations between social networks and life satisfaction among older Japanese: Does birth cohort make a difference?. *Psychology and aging*, 30(4): 952.

Kojima, G., Iliffe, S., Jivraj, S., & Walters, K. (2016) Association between frailty and quality of life among community-dwelling older people: a systematic review and meta-analysis. *J Epidemiol Community Health*, 70(7): 716-721.

Koopmans, T. A., Geleijnse, J. M., Zitman, F. G., & Giltay, E. J. (2010) Effects of happiness on all-cause mortality during 15 years of follow-up: The Arnhem Elderly Study. *Journal of Happiness Studies*, 11(1): 113-124.

Koushede, V. et al. (2018). *Measuring mental well-being in Denmark: validation of the original and short version of Warwick-Edinburgh Mental Well-Being Scale (WEMWBS and SWEMWBS) and cross-cultural comparison across four European settings*. Psychiatry Research. 271. 10.1016/j.psychres.2018.12.003.

Kozma, A., & Stones, M. J. (1983) Predictors of happiness. *Journal of Gerontology*, 38(5): 626-628.

Lamers, S.M.A., Westerhof, G.J., Bohlmeijer, E.T., ten Klooster, P.M., & Keyes, C.L.M. (2010). *Evaluating the psychometric properties of the Mental Health Continuum-Short Form (MHC-SF)*. Journal of Clinical Psychology, 67, 99-110

Lang, I., Llewellyn, D., Hubbard, R., Langa, K., & Melzer, D. (2011) Income and the midlife peak in common mental disorder prevalence. *Psychological Medicine*, 41(7): 1365-1372. doi:10.1017/S0033291710002060

Lawton, M. P., Kleban, M. H., Dean, J., Rajagopal, D. & Parmelee, P. A. (1992). The factorial generality of brief positive and negative affect measures. *Journal of Gerontology*, 47: 228–P237.

Layard, R. (2006) Happiness and public policy: A challenge to the profession. *The Economic Journal*, 116(510): C24-C33.

Layard. R (2013), *Mental Illness and Unhappiness*, World Happiness Report 2013

Lee, Y. J., & Hung, W. L. (2011) The relationship between exercise participation and well-being of the retired elderly. *Aging & mental health*, 15(7): 873-881.

Levin, C. (2000) Social Functioning. In: Kane, R. L., Kane, R. A. with the assistance of Eells, M. (eds.) *Assessing Older Persons: Measures, Meaning and Practical Applications*. New York, Oxford: Oxford University Press: 173

Levin, J. S., Markides, K. S., & Ray, L. A. (1996) Religious attendance and psychological well-being in Mexican Americans: A panel analysis of three-generations data. *The Gerontologist*, 36(4): 454-463.

Li, C. P. (2013) Life satisfaction as a predictor of mortality hazard among elderly people in the United Kingdom and Taiwan. *Journal of Nursing Research*, 21(1): 26-38.

Li, S., Xie, Z., Shao, J., Xiao, C., Tian, L., Zhao, R., Gong, J., Han, J., Wang, Y., Han, C. & Dang, L. (2012) Subjective well-being of the elderly in Xi Cheng District, Beijing. *Shanghai archives of psychiatry*, 24(6): 335-345.

Li, S-C., Ulman, L., Bernhard, H., Gisa, A., Wolfgang, P., & Baltes, P. B. (2004) Transformations in the Couplings Among Intellectual Abilities and Constituent Cognitive Processes Across the Life Span. *Psychological science*, 15: 155-63. 10.1111/j.0956-7976.2004.01503003.x.

Lim, H. J., Min, D. K., Thorpe, L., & Lee, C. H. (2017) Trajectories of life satisfaction and their predictors among Korean older adults. *BMC geriatrics*, 17(1): 89.

López Ulloa, B. F., Møller, V., & Sousa-Poza, A. (2013) How Does Subjective Well-Being Evolve with Age? A Literature Review. *Journal of Population Ageing*, 6: 227-246. 10.1007/s12062-013-9085-0.

Lowis, M. J., Edwards, A. C., & Singlehurst, H. M. (2010) The relationship between preretirement occupation and older adults' life satisfaction and self-rated health. *The Journal of psychology*, 145(1): 59-72.

Maddox, G. L. & Wiley, J. (1976) Scope, concepts and methods in the study of aging. In: Binstock R. H. & Shanas E. (eds.) *Handbook of aging and the social sciences*. 1st ed. New York: Van Nostrand Reinhold: 3-34.

Marcoen, A., Van Cotthem, K., Billiet, K., & Beyers, W. (2002) Dimensies van subjectief welbevinden bij ouderen. *Tijdschrift voor Gerontologie en Geriatrie*, 2002; 33: 156–165. PubMed

Margelisch, K., Schneewind, K. A., Violette, J., & Perrig-Chiello, P. (2017) Marital stability, satisfaction and well-being in old age: variability and continuity in long-term continuously married older persons. *Aging & mental health*, 21(4): 389-398.

Markides, K. S., & Lee, D. J. (1990) Predictors of Weil-Being and Functioning in Older Mexican Americans and Anglos: An Eight-Year Follow-Up. *Journal of Gerontology*, 45(2): S69-S73.

Mann, A. H., Schneider, J., Mozley, C. G., Levin, E., Blizard, R., Netten, A., Kharicha, K., Egelstaff, R., Abbey, A., & Todd, C. (2000) Depression and the response of residential homes to physical health needs. *International Journal of Geriatric Psychiatry*, 15(12): 1105-1112. https://doi.org/10.1002/1099-1166(200012)15:12<1105::AID-GPS252>3.0.CO;2-W

Marsiske M., Lang F., Baltes B. P., & Baltes M. M. (1995), Selective optimization with compensation: Life-span perspectives on successful human development. In R. Dixon & L. Bäckman (eds.), *Psychological compensation: managing losses and promoting gains*. Hillsdale, NJ: Erlbaum. pp. 35-79

McAdams, K. K., Lucas, R. E., & Donnellan, M. B. (2012) The role of domain satisfaction in explaining the paradoxical association between life satisfaction and age. *Social Indicators Research*, 109(2): 295-303. http://dx.doi.org/10.1007/s11205-011-9903-9

McAuley, E., Blissmer, B., Marquez, D. X., Jerome, G. J., Kramer, A. F., & Katula, J. (2000) Social relations, physical activity, and well-being in older adults. *Preventive medicine*, 31(5): 608-617.

Merz, E. M., & Consedine, N. S. (2009) The association of family support and wellbeing in later life depends on adult attachment style. *Attachment & human development*, 11(2): 203-221.

Merz, E. M., & Huxhold, O. (2010) Wellbeing depends on social relationship characteristics: Comparing different types and providers of support to older adults. *Ageing & Society*, 30(5): 843-857.

Mete, C. (2005) Predictors of elderly mortality: health status, socio-economic characteristics and social determinants of health, *Health Economics*, 14: 135–148. DOI:10.1002/hec.892

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L. A., & PRISMA-P Group (2015) Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic reviews*, 4(1): 1-9. doi:10.1186/2046-4053-4-1

Momtaz, Y. A., Ibrahim, R., Hamid, T. A., & Yahaya, N. (2010) Mediating Effects of Social and Personal Religiosity on the Psychological Well Being of Widowed Elderly People. *OMEGA - Journal of Death and Dying*, 61(2): 145–162. https://doi.org/10.2190/OM.61.2.d

Momtaz, Y. A., Hamid, T. A., Haron, S. A., & Bagat, M. F. (2016) Flourishing in Later Life. *Archives of Gerontology and Geriatrics,* 63: 85–91. https://doi.org/10.1016/j.archger.2015.11.001.

Mozley, C., Sutcliffe, C., Bagley, H., Cordingley, L., Challis, D., Huxley, P. J., & Burns, A. (2004) *Towards quality care: outcomes for older people in care homes*. Aldershot, Ashgate, ISBN: 0754631729

Mroczek, D. K. & Kolarz, C. M. (1998) The effect of age on positive and negative affect: A developmental perspective on happiness. *Journal of Personality and Social Psychology*, 75: 1333–1349.

Mroczek, D. & Spiro, A. (2005) Change in life satisfaction during adulthood: findings from the Veterans affairs normative aging study. *Journal of Personality and Social Psychology*, 88: 189-202.

Nabi H. et al. (2008) *Positive and negative affect and risk of coronary heart disease: Whitehall II prospective cohort study* BMJ 2008; 337 :a118

Netz, Y. & Wu, M-J. (2005) Physical Activity and Psychological Well-Being in Advanced Age: A Meta-Analysis of Intervention Studies. *Psychology and Aging*, 20(2): 272–284. DOI: 10.1037/0882-7974.20.2.272

Neugarten, B. L., Havighurst, R. J., & Tobin, S. S. (1961) The Measurement of Life Satisfaction. *Journal of Gerontology*, 16(2): 134–143. https://doi.org/10.1093/geronj/16.2.134

Ng Fat, L., Scholes, S., Boniface, S., Mindell J., & Stewart-Brown S. (2017) *Evaluating and establishing the national norms for mental well-being using the short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS): findings from the Health Survey for England.* Quality of Life Research, 26(5), 1129-1144.

Ng, S. T., Tey, N. P., & Asadullah, M. N. (2017) What matters for life satisfaction among the oldest-old? Evidence from China. *PloS one*, 12(2): e0171799.

Ng, T. P. et al. (2015) *Nutritional, Physical, Cognitive, and Combination Interventions and Frailty Reversal Among Older Adults: A Randomized Controlled Trial*. The American Journal of Medicine, Vol 128, No 11, November 2015. https://doi.org/10.1016/j.amjmed.2015.06.017

NICE Glossary (2019) National Institute for Health and Care Excellence. Available from: https://www.nice.org.uk/glossary? (Accessed 26 August 2019)

Ní Mhaoláin, A., Gallagher, D., O Connell, H., Chin, A., Bruce, I., Hamilton, F., Tehee, E., Coen, R., Coakley, D., Cunningham, C., Walsh, B. J., & Lawlor, B. (2012). Subjective well-being amongst community-dwelling elders: What determines satisfaction with life? Findings from the Dublin Healthy Aging Study. *International Psychogeriatrics*, 24(2): 316-323. doi:10.1017/S1041610211001360

Nyqvist, F., Forsman, A. K., Giuntoli, G., & Cattan, M. (2013) Social capital as a resource for mental well-being in older people: A systematic review. *Aging & Mental Health*, 17(4): 394-410, DOI: 10.1080/13607863.2012.742490

O'Connell M. L., Coppinger T., McCarthy A. L. (2020) The role of nutrition and physical activity in frailty: A review. Clin Nutr ESPEN. 2020 Feb; 35:1-11. doi: 10.1016/j.clnesp.2019.11.003. Epub 2019 Dec 6. Review. PubMed PMID: 31987100

Ohrnberger, J., Fichera, E., Sutton, M. (2017). *The relationship between physical and mental health: A mediation analysis.* Social Science & Medicine, 195:42-49. https://doi.org/10.1016/j.socscimed.2017.11.008

Okabayashi, H., Liang, J., Krause, N., Akiyama, H., & Sugisawa, H. (2004) Mental health among older adults in Japan: do sources of social support and negative interaction make a difference?. *Social science & medicine*, 59(11): 2259-2270.

Okely, J. A., & Gale, C. R. (2016). *Well-Being and Chronic Disease Incidence: The English Longitudinal Study of Ageing*. Psychosomatic medicine, 78(3), 335–344. https://doi.org/10.1097/PSY.0000000000000279

Olsson, L. A., Hurtig-Wennlöf, A., & Nilsson, T. K. (2014) Subjective well-being in Swedish active seniors and its relationship with physical activity and commonly available biomarkers. *Clinical interventions in aging*, 9: 1233-1239.

ONS (2012) *Measuring National Well-being, Health, 2012*. Office for National Statistics

ONS (2013) *Measuring National Well-being - Review of domains and measures, 2013*. Office for National Statistics

ONS (2016) *Measuring National Well-being: At what age is Personal Well-being the highest?* Office for National Statistics

ONS (2017) *Overview of the UK population: July 2017*. Office for National Statistics

ONS (2018) *Methodology: Personal well-being user guidance*, 2018. Office for National Statistics

Ormsby, J., Stanley, M., & Jaworski, K. (2010) Older men ’ s participation in community- based men’s sheds programmes. *Health & Social Care in the Community*, 18: 607-613. doi:10.1111/j.1365-2524.2010.00932.x

Ostir, G. V., Markides, K. S., Black, S. A., & Goodwin, J. S. (2000) Emotional well‐being predicts subsequent functional independence and survival. *Journal of the American Geriatrics Society*, 48(5): 473-478.

Ostir, G. V., Markides, K. S., Peek, M. K., & Goodwin, J. S. (2001) The association between emotional well-being and the incidence of stroke in older adults. *Psychosomatic medicine*, 63(2) : 210-215.

Otero-Rodríguez, A., León-Muñoz, L. M., Balboa-Castillo, T., Banegas, J. R., Rodríguez-Artalejo, F., & Guallar-Castillón, P. (2010) Change in health-related quality of life as a predictor of mortality in the older adults. *Quality of Life Research*, 19(1): 15-23.

Palgi, Y., Shrira, A., & Zaslavsky, O. (2015) Quality of life attenuates age-related decline in functional status of older adults. *Quality of Life Research*, 24(8): 1835-1843.

Park, J., Roh, S., & Yeo, Y. (2012) Religiosity, Social Support, and Life Satisfaction Among Elderly Korean Immigrants. *The Gerontologist*, 52(5): 641–649. https://doi.org/10.1093/geront/gnr103

Park, M., Kim, J., & Park, B. (2014) The effects of health on the life satisfaction of poor and nonpoor older women in Korea. *Health care for women international*, 35(11-12): 1287-1302.

Paul, K. I., & Moser, K. (2009) Unemployment impairs mental health: Meta-analyses. *Journal of Vocational behavior*, 74(3): 264-282.

Pearson, A., White, H., Bath-Hextall, F., Salmond, S., Apostolo, J., & Kirkpatrick, P. (2015) A mixed-methods approach to systematic reviews. *International Journal of Evidence-Based Healthcare*, 13(3): 121-131. https://doi.org/10.1097/XEB.0000000000000052

Petersen, R. C., Smith, G. E., Waring, S. C., Ivnik, R. J., Tangalos, E. G., & Kokmen, E. (1999) Mild Cognitive Impairment Clinical Characterization and Outcome, *Arch Neurol*, 56(3): 303-308, doi:10.1001/archneur.56.3.303

Pickard, L. (2015) A growing care gap? The supply of unpaid care for older people by their adult children in England to 2032. *Ageing and Society*, 35(1): 96-123. doi:10.1017/S0144686X13000512

Pinquart, M. & Sörensen, S. (2000) Influences of socio-economic status, social network, and competence on subjective well-being in later life. *Psychology and Aging*, 15(2): 187-224. DOT: 10.1037//0882- 7974.15.2.187

Pluye, P., Robert, E., Cargo, M., Bartlett, G., O'Cathain, A., Griffiths, F., Boardman, F., Gagnon, M.P., & Rousseau, M.C. (2011) Proposal: A mixed methods appraisal tool for systematic mixed studies reviews. Retrieved from http://mixedmethodsappraisaltoolpublic.pbworks.com. Archived by WebCite® at http://www.webcitation.org/5tTRTc9yJ

Pluye P. & Hong Q. N. (2014), Combining the power of stories and the power of numbers: Mixed methods research and mixed studies reviews, *Annual Review of Public Health*, 35: 29-45.

Prasoon, R. & Chaturvedi, K. R. (2016) Life Satisfaction: A literature Review. *The Researcher- International Journal of Management Humanities and Social Sciences*, 1(2): 25-32

Prince M, Patel V, Saxena S, Maj M, Maselko J, Phillips MR, Rahman A (2007). *No health without mental health*. The Lancet, vol 370, no 9590, pp 859–77

Riediger, M., Li, S-C., & Lindenberger, U. (2006) Selection, optimization, and compensation as developmental mechanisms of adaptive resource allocation: review and preview. In: Birren, J. E. & Schaie, K.W. (eds.) *Handbook of the Psychology of Aging*. 6th edn. Elsevier, Amsterdam: 289–314.

Roebuck, J. (1979) When does" old age begin?: The evolution of the English definition. *Journal of Social History*, 12(3): 416-428.

Rogers NT, Marshall A, Roberts CH, Demakakos P, Steptoe A, et al. (2017) *Physical activity and trajectories of frailty among older adults: Evidence from the English Longitudinal Study of Ageing*. PLOS ONE 12(2): e0170878. https://doi.org/10.1371/journal.pone.0170878

Ross, C. E., & Wu, C. L. (1996) Education, age, and the cumulative advantage in health. *Journal of health and social behavior*, 104-120.

Rowe, J. W. & Kahn, R. L. (1987) Human aging: Usual and successful. *Science*, 237(4811): 143-149. http://dx.doi.org/10.1126/science.3299702

Rowe, J. W. & Kahn, R. L. (1997) Successful Aging. *The Gerontologist* 37 (4): 433–40.

Ryan, R. M. & Deci, E. L. (2001) On Happiness and Human Potentials: A Review of Research on Hedonic and Eudaimonic Well-Being. *Annual Review of Psychology*, 52: 141-166.

Ryff, C. D. (1989) Happiness is everything, or is it? Explorations on the meaning of psychological well-being. *Journal of Personality and Social Psychology*, 57: 1069–1081

Ryff, C. D. (1995) Psychological Well-Being in Adult Life. *Current Directions in Psychological Science*, 4 (4): 99-104

Ryff, C. D. & Keyes, C. L. M. (1995) The structure of psychological well-being revisited. *Journal of Personality and Social Psychology*, 69: 719–727

Sabatini, F. (2011) *The relationship between happiness and health: evidence from Italy*. Munich Personal RePEc Archive, paper no. 30948

Sadler, M. E., Miller, C. J., Christensen, K., & McGue, M. (2011) Subjective wellbeing and longevity: a co-twin control study. *Twin Research and Human Genetics*, 14(3): 249-256. doi:10.1375/twin.14.3.249

Satariano, W. A. (2013) Healthy Aging in the U.S.. In Scharlach, A. E. & Hoshino, K. (eds.) *Healthy Aging in Sociocultural Context,* Routledge Advances in Sociology. New York, Routledge: 14–21.

Schaie K. W. (2008), Handbook of emotional disorders in later life: Assessment and treatment. edited by Laidlaw K. and Knight B. G., *Oxford University Press*, Oxford, pp 3-32.

Schaie, K.W. (2008) Historical processes and patterns of cognitive aging. In: Hofer, S. M. & Alwin, D. F. (eds.) *Handbook of cognitive aging: Interdisciplinary perspectives*. Sage. Thousand Oaks. CA: 368–383.

Schaie, K. W. & Hofer, S. M. (2001) Longitudinal studies in research on aging. In Birren, J. E. & Schaie, K. W. (eds.). *Handbook of the psychology of aging*. 5th ed. San Diego, CA: Academic Press: 53-77

Schaie, K.W. & Willis, S. L. (2000) A stage theory model of adult cognitive development revisited. In Rubinstein, R., Moss, M. and Kleban, M. (Eds.) *The many dimensions of aging: Essays in honor of M. Powell Lawton.* New York: Springer Publishing Co: 175-193.

Schuessler, K. F. & Fisher, G. A. (1985) Quality of life research and sociology. *Annual Review of Sociology*, 11: 129-149

Schwandt, H. (2015) Unmet Aspirations as an Explanation for the Age U-shape in Wellbeing. *Journal of Economic Behavior & Organization*, 122: 75-87. 10.1016/j.jebo.2015.11.011.

Sexton, E. et al. (2014). *CASP-19 special section: How does chronic disease status affect CASP quality of life at older ages? Examining the WHO ICF disability domains as mediators of this relationship.* Aging & mental health. 19. 1-12. 10.1080/13607863.2014.955457.

Shea, B. J., Grimshaw, J. M., Wells, G. A., Boers, M., Andersson, N., Hamel, C., Porter, A. C., Tugwell, P., Moher, D., Bouter, L. M. (2007) Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. *BMC medical research methodology*, 7(10): 1-7. doi:10.1186/1471-2288-7-10

Shin, S. H. and S. R. Sok (2012). "A comparison of the factors influencing life satisfaction between Korean older people living with family and living alone." *International nursing review* 59(2): 252-258.

Silverstein, M., Cong, Z., & Li, S. (2006) Intergenerational transfers and living arrangements of older people in rural China: Consequences for psychological well-being. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 61(5): S256-S266.

Sörensen, S., Pinquart, M., & Duberstein, P. (2002) How Effective Are Interventions With Caregivers? An Updated Meta-Analysis. *The Gerontologist*, 42(3): 356–372. https://doi.org/10.1093/geront/42.3.356

Stare, J., & Maucort-Boulch, D. (2016) Odds ratio, hazard ratio and relative risk. *Metodoloski zvezki*, 13(1): 59-67.

Stathi, A., Fox, K. R., & McKenna, J. (2002) Physical activity and dimensions of subjective well-being in older adults. *Journal of aging and physical activity*, 10(1): 76-92.

Steinmo, S., Hagger-Johnson, G., & Shahab, L. (2014). *Bidirectional association between mental health and physical activity in older adults: Whitehall II prospective cohort study*. Preventive medicine, 66, 74-9 .

Steptoe, A. & Wardle J. (2011) Positive affect measured using ecological momentary assessment and survival in older men and women. *Proceedings of the National Academy of Sciences*, 108(45): 18244-18248.

Steptoe, A., Demakakos, P., de Oliveira, C., & Wardle, J. (2012) Distinctive Biological Correlates of Positive Psychological Well-Being in Older Men and Women. *Psychosomatic medicine*, 74: 501-508. 10.1097/PSY.0b013e31824f82c8.

Steptoe, A., Deaton, A., & Stone, A. A. (2015) Subjective wellbeing, health, and ageing. *Lancet (London, England)*, 385(9968): 640–648. doi:10.1016/S0140-6736(13)61489-0

Steves C. J., Spector T. D., & Jackson S. H. D. (2012) Ageing, genes, environment and epigenetics: what twin studies tell us now, and in the future. *Age and Ageing*, 41(5): 581–586. doi: 10.1093/ageing/afs097

Stewart-Brown, S. L., Platt, S., Tennant, A., Maheswaran, H., Parkinson, J., Weich, S., Tennant, R., Taggart, F. & Clarke, A. (2011) The Warwick-Edinburgh Mental Well-being Scale (WEMWBS): a valid and reliable tool for measuring mental well-being in diverse populations and projects. *J Epidemiol Community Health*, 65(Suppl 2): A38-A39.

Stewart-Brown, S. L. (2015) Measuring wellbeing: what does the Warwick-Edinburgh Mental Well-being Scale have to offer integrated care? *European Journal of Integrative Medicine*, 7 (4): 384-388. doi:10.1016/j.eujim.2014.08.004

Stewart-Brown, S. (2017) Population level: Wellbeing in the general population, In Slade, M., Oades, L. & Jarden, A. (eds.) *Wellbeing, Recovery and Mental Health*, Cambridge University Press, section 3, chapter 18: 215-230. DOI: https://0-doi-org.pugwash.lib.warwick.ac.uk/10.1017/9781316339275.019

Stewart-Brown, S. (2018a) Resilience and well-being. In Bhugra, D., Bhui, K., Wong, S. Y. S., and Gilman S. (eds). *Oxford Textbook of Public Mental Health*, Oxford: Oxford University Press: 503-511.

Stewart-Brown, S. (2018b) *The Warwick-Edinburgh Mental Wellbeing Scales - (S)WEMWBS*. Warwick Medical School, University of Warwick. Available from: https://warwick.ac.uk/fac/sci/med/research/platform/wemwbs/ (Accessed 26 August 2019)

Stone A. A., Schwartz J. E., Broderick J. E., & Deaton A. (2010) A snapshot of the age distribution of psychological well-being in the United States. *Proceedings of the National Academy of Sciences U.S.A*. 107:9985-9990 (2010)

Sun, W., Aodeng, S., Tanimoto, Y., Watanabe, M., Han, J., Wang, B., Yu, L. & Kono, K. (2015) Quality of life (QOL) of the community-dwelling elderly and associated factors: A population-based study in urban areas of China. *Archives of gerontology and geriatrics* 60(2): 311-316.

Sun, X., Liu, K. U. N., Webber, M., & Shi, L. (2017) Individual social capital and health-related quality of life among older rural Chinese. *Ageing and Society* 37(2): 221-242.

Tajvar, M., Arab, M., & Montazeri, A. (2008) Determinants of health-related quality of life in elderly in Tehran, Iran. *BMC public health* 8: 323.

Tampubolon, G. (2015) Delineating the third age: joint models of older people's quality of life and attrition in Britain 2002-2010. *Aging & Mental Health*, 19(7): 576-583.

Taneva, S. (2016) What is psychological well-being and how it changes throughout the employment cycle? In Monteiro, I. & Iguti, A. M. (eds.) *Trabalho, saúde e sustentabilidade: construindo cidadania (Work, health and sustainability: building* *citizenship; Travail, santé et développement durable: la construction de la citoyenneté)*, Brazil, 1st: 83 - 90.

Tennant, R., Hiller, L., Fishwick, R., Platt, S., Joseph, S., Weich, S., Parkinson, J., & Stewart-Brown, S. (2007) The Warwick-Edinburgh Mental Well-being Scale (WEMWBS) development and UK validation, *Health and Quality of Life Outcomes*, 5(63): 1-13. doi:10.1186/1477-7525-5-63

Thanakwang, K., Ingersoll-Dayton, B., & Soonthorndhada, K. (2012) The relationships among family, friends, and psychological well-being for Thai elderly. *Aging & mental health*, 16(8): 993-1003.

Tsai, S. Y., Chi, L. Y., Lee, C. H., & Chou, P. (2007) Health-related quality of life as a predictor of mortality among community-dwelling older persons. *European journal of epidemiology*, 22(1): 19.

Ulloa B.F.L., Moller V. & Sousa-Poza A. (2013) How Does Subjective Well-Being Evolve with Age? A Literature Review. *Journal of Population Ageing*, (6): 227-245. https://doi.org/10.1007/s12062-013-9085-0

UN (2001). Personal correspondence with Marybeth Weinberger, Chief, *United Nations Population Division*, *Population and Development Section*.

Ura, K., Alkire, S., Zangmo, T., & Wangdi, K. (2012) *A Short Guide to Gross National Happiness Index*, The Centre for Bhutan Studies, ISBN·978-99936-14-66-1

Vagetti, G. C., Barbosa Filho, V. C., Moreira, N. B., de Oliveira, V., Mazzardo, O., & de Campos, W. (2015) The association between physical activity and quality of life domains among older women. *Journal of aging and physical activity* 23(4): 524-533.

Van Hoecke, A. S., Delecluse, C., Bogaerts, A., & Boen, F. (2014) Effects of need-supportive physical activity counseling on well-being: a 2-year follow-up among sedentary older adults. *Journal of Physical Activity and Health* 11(8): 1492-1502.

Van Landeghem, B. (2012) A test for convexity of human well-being over the lifecycle: longitudinal evidence from a 20-year panel. *Journal of Economic Behavior and Organization*: 571-585.

Van Lente, E., Barry, M. M., Molcho, M., Morgan, K., Watson, D., Harrington, J., & McGee, H. (2012) Measuring population mental health and social well-being. *International Journal of Public Health*, 57(2): 421-430. DOI 10.1007/s00038-011-0317-x

Veenhoven, R. (2008) Healthy happiness: Effects of happiness on physical health and the consequences for preventive health care. *Journal of happiness studies*, 9(3): 449-469. 10.1007/s10902-006-9042-1.

Veit, C. T., & Ware, J. E. (1983) The structure of psychological distress and well-being in general populations. *Journal of Consulting and Clinical Psychology*, 51(5): 730-742.

Vella, S. A., Swann, C., Allen, M. S., Schweickle, M. J., Magee, C. A. (2017) *Bidirectional Associations between Sport Involvement and Mental Health in Adolescence*. Medicine and Science in Sports and Exercise. 2017 Apr;49(4):687-694. DOI: 10.1249/mss.0000000000001142.

Von Bonsdorff, M. B. & Rantanen, T. (2011) Benefits of formal voluntary work among older people. A review. *Aging Clinical and Experimental Research*, 23(3): 162-169.

von Humboldt, S., & Leal, I. (2014) Adjustment to aging in late adulthood: A systematic review. *International Journal of Gerontology*, 8(3): 108-113. https://doi.org/10.1016/j.ijge.2014.03.003.

Waddell, E. L., & Jacobs-Lawson, J. M. (2010) Predicting positive well-being in older men and women. *International journal of aging & human development*, 70(3): 181-197.

Ware, J. E., Kk, S., Kosinski, M. A., & Gandek, B. G. (1993) *SF36 Health Survey: Manual and Interpretation Guide*. Lincoln, RI: Quality Metric, Inc, 1993. 30.

Ware, J., Kosinski, M., & Keller, S. D. (1995) How to score the SF-12 physical and mental health summary scales. Boston, MA: *The Health Institute*, New England Medical Center, Second Edition: 11-25.

Watson, D., Clark, L. A., & Tellegen, A. (1988) Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology*, 54(6): 1063-1070.

Weich, S., Brugha, T., King, M., McManus, S., Bebbington, P., Jenkins, R., . . . Stewart-Brown, S. (2011). *Mental well-being and mental illness: Findings from the Adult Psychiatric Morbidity Survey for England 2007*. British Journal of Psychiatry, 199(1), 23-28. doi:10.1192/bjp.bp.111.091496

Well, G., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M., & Tugwell, P. (2012) *The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses*. [Online] Available from: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp (January, 2013)

Wernher, I. & Lipsky, M. S. (2015) Psychological theories of aging. *Disease-A-Month*, 61(11): 480-488. doi:10.1016/j.disamonth.2015.09.004.

Westerhof, G. J., & Keyes, C. L. (2010) Mental illness and mental health: The two continua model across the lifespan. *Journal of adult development*, 17(2): 110–119. DOI 10.1007/s10804-009-9082-y

Wheeler, J. A., Gorey, K. M., & Greenblatt, B. (1998) The beneficial effects of volunteering for older volunteers and the people they serve: A meta-analysis. *The International Journal of Aging and Human Development*, 47(1): 69-79.

WHO (1948) *Preamble to the Constitution of WHO as adopted by the International Health Conference*, New York, 19 June - 22 July 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of WHO, no. 2, p. 100) and entered into force on 7 April 1948.

WHO (1998) *Wellbeing Measures in Primary Health Care/The Depcare Project*. WHO Regional Office for Europe: Copenhagen.

WHO (1998), *Annotated Bibliography of the WHO Quality of Life Assessment Instrument – WHOQOL*, Department of Mental Health, World Health Organization

WHO (2006a), World Health Organization. Available from: http://www.who.int/whosis/whostat2006DefinitionsAndMetadata.pdf. (Accessed 26 August 2019)

WHO (2006b), The WHOQOL-OLD module – manual, *WHO*, European office, May 2006, https://www.who.int/mental_health/evidence/WHOQOL_OLD_Manual.pdf?ua=1

WHO (2014) *Mental health: a state of well-being*. World Health Organization. Available from: https://www.who.int/features/factfiles/mental_health/en/ (Accessed 26 August 2019)

WHO (2015) *World report on ageing and health*. WHO Press. World Health Organization.

Williams, G. C. (1957) Pleitropy, natural selection, and the evolution of senescence. *Evolution*, 11: 398 – 411.

Wilson, M. et al. (2015) The Scottish Health Survey: Topic Report Mental Health and Wellbeing. Topic Report, Mental Health and Wellbeing, A Official Statistics Publication for Scotland, *The Scottish Government*, 2015. http://www.gov.scot/Resource/0046/00469088.pdf

Windle, G., Hughes, D., Linck, P., Russell, I., & Woods, B. (2010) Is exercise effective in promoting mental well-being in older age? A systematic review. *Aging & Mental Health*, 14(6): 652-669. DOI: 10.1080/13607861003713232

Windle, G., & Woods, R. T. (2004) Variations in subjective wellbeing: The mediating role of a psychological resource. *Ageing & Society*, 24(4): 583-602.

Wittenberg, R., Hu, B., Hancock, R., Morciano, M., Comas-Herrera, A., Malley, J., & King, D. (2011) *Projections of Demand for and Costs of Social Care for Older People in England, 2010 to 2030, under Current and Alternative Funding Systems*. Personal Social Services Research Unit: PSSRU Discussion paper 2811/2

Woods, B. (2008) Normal and abnormal ageing. In: Laidlaw K. & Knight B. G. (eds.) *Handbook of emotional disorders in later life: Assessment and treatment*. Oxford University Press, Oxford: 33-58

Wunder, C., Wiencierz, A., Schwarze, J., Küchenhoff, H., & Kleyer, S. (2009) *Well-Being over the Life Span: Semiparametric Evidence from British and German*

*Longitudinal Data*. IZA Discussion Papers No. 4155, Institute for the Study of Labor (IZA)

Yates, L. B., Djoussé, L., Kurth, T., Buring, J. E., & Gaziano, J. M. (2008) Exceptional longevity in men: modifiable factors associated with survival and function to age 90 years. *Archives of Internal Medicine*, 168(3): 284-290. doi:10.1001/archinternmed.2007.77

Ye, M., & Chen, Y. (2014) The influence of domestic living arrangement and neighborhood identity on mental health among urban Chinese elders. *Aging & mental health*, 18(1): 40-50.

Yoon, D. P., & Lee, E. K. O. (2006) The impact of religiousness, spirituality, and social support on psychological well-being among older adults in rural areas. *Journal of Gerontological Social Work*, 48(3-4): 281-298.

Yun, J. (1982) A Study of Tool Development for Living Satisfaction of Elderly. *Proceeding book of Korean Psychiatric Academic Association*: 26–30

Zimmer, Z., & Lin, H. S. (1996) Leisure activity and well-being among the elderly in Taiwan: Testing hypotheses in an Asian setting. *Journal of cross-cultural gerontology* 11(2): 167-186.

# APPENDIX A. MEASURES AND SCORING SYSTEM

## 1. WEMWBS & SWEMWBS

### The Warwick-Edinburgh Mental Well-being Scale (WEMWBS)

Below are some statements about feelings and thoughts.

Please tick the box that best describes your experience of each over the last 2 weeks

| STATEMENTS | None of the time | Rarely | Some of the time | Often | All of the time |
|---|---|---|---|---|---|
| I've been feeling optimistic about the future | 1 | 2 | 3 | 4 | 5 |
| I've been feeling useful | 1 | 2 | 3 | 4 | 5 |
| I've been feeling relaxed | 1 | 2 | 3 | 4 | 5 |
| I've been feeling interested in other people | 1 | 2 | 3 | 4 | 5 |
| I've had energy to spare | 1 | 2 | 3 | 4 | 5 |
| I've been dealing with problems well | 1 | 2 | 3 | 4 | 5 |
| I've been thinking clearly | 1 | 2 | 3 | 4 | 5 |
| I've been feeling good about myself | 1 | 2 | 3 | 4 | 5 |
| I've been feeling close to other people | 1 | 2 | 3 | 4 | 5 |
| I've been feeling confident | 1 | 2 | 3 | 4 | 5 |
| I've been able to make up my own mind about things | 1 | 2 | 3 | 4 | 5 |
| I've been feeling loved | 1 | 2 | 3 | 4 | 5 |
| I've been interested in new things | 1 | 2 | 3 | 4 | 5 |
| I've been feeling cheerful | 1 | 2 | 3 | 4 | 5 |

# The Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS)

**Below are some statements about feelings and thoughts.**

**Please tick the box that best describes your experience of each over the last 2 weeks**

| STATEMENTS | None of the time | Rarely | Some of the time | Often | All of the time |
|---|---|---|---|---|---|
| I've been feeling optimistic about the future | 1 | 2 | 3 | 4 | 5 |
| I've been feeling useful | 1 | 2 | 3 | 4 | 5 |
| I've been feeling relaxed | 1 | 2 | 3 | 4 | 5 |
| I've been dealing with problems well | 1 | 2 | 3 | 4 | 5 |
| I've been thinking clearly | 1 | 2 | 3 | 4 | 5 |
| I've been feeling close to other people | 1 | 2 | 3 | 4 | 5 |
| I've been able to make up my own mind about things | 1 | 2 | 3 | 4 | 5 |

## 2. SF-12

**SF-12 HEALTH SURVEY (STANDARD)**

**INSTRUCTIONS:** This questionnaire asks for your views about your health. This information will help keep track of how you feel and how well you are able to do your usual activities.

Please answer every question by marking one box. If you are unsure about how to answer, please give the best answer you can.

1. In general, would you say your health is:

| ☐ | ☐ | ☐ | ☐ | ☐ |
|---|---|---|---|---|
| **Excellent** | **Very good** | **Good** | **Fair** | **Poor** |

The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

| | **Yes, Limited A Lot** | **Yes, Limited A Little** | **No, Not Limited At All** |
|---|---|---|---|
| 2. **Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf | ☐ | ☐ | ☐ |
| 3. Climbing **several** flights of stairs | ☐ | ☐ | ☐ |

During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

| | **YES** | **NO** |
|---|---|---|
| 4. **Accomplished less** than you would like | ☐ | ☐ |
| 5. Were limited in the **kind** of work or other activities | ☐ | ☐ |

During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

| | YES | NO |
|---|---|---|
| 6. **Accomplished less** than you would like | ☐ | ☐ |
| 7. Didn't do work or other activities as **carefully** as usual | ☐ | ☐ |

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

| ☐ | ☐ | ☐ | ☐ | ☐ |
|---|---|---|---|---|
| **Not at all** | **A little bit** | **Moderately** | **Quite a bit** | **Extremely** |

These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks -

| | **All of the Time** | **Most of the Time** | **A Good Bit of the Time** | **Some of the Time** | **A Little of the Time** | **None of the Time** |
|---|---|---|---|---|---|---|
| 9. Have you felt calm and peaceful? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10. Did you have a lot of energy? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 11. Have you felt downhearted and blue? | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

12. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

| ☐ | ☐ | ☐ | ☐ | ☐ |
|---|---|---|---|---|
| **All of the time** | **Most of the time** | **Some of the time** | **A little of the time** | **None of the time** |

# 3. GHQ-12 Caseness

**12 questions of the General Health Questionnaire (GHQ-12)-Caseness**

| | 0 | 0 | 1 | 1 |
|---|---|---|---|---|
| **CONCENTRATION** | better than usual | same as usual | less than usual | much less than usual |
| **LOSS OF SLEEP** | not at all | no more than usual | rather more than usual | much more than usual |
| **PLAYING A USEFUL ROLE** | more than usual | same as usual | less than usual | much less than usual |
| **CAPABLE OF MAKING DECISIONS** | more than usual | same as usual | less than usual | much less than usual |
| **CONSTANTLY UNDER STRAIN** | not at all | no more than usual | rather more than usual | much more than usual |
| **PROBLEM OVERCOMING DIFFICULTIES** | not at all | no more than usual | rather more than usual | much more than usual |
| **ENJOY DAY-TO-DAY ACTIVITIES** | more than usual | same as usual | less than usual | much less than usual |
| **ABILITY TO FACE PROBLEMS** | more than usual | same as usual | less than usual | much less than usual |
| **UNHAPPY OR DEPRESSED** | not at all | no more than usual | rather more than usual | much more than usual |
| **LOSING CONFIDENCE** | not at all | no more than usual | rather more than usual | much more than usual |
| **BELIEVE IN SELF-WORTH** | not at all | no more than usual | rather more than usual | much more than usual |
| **GENERAL HAPPINESS** | more than usual | same as usual | less than usual | much less than usual |

## 4. Ryff's Psychological Well-Being Scales – 42 items version

### Ryff's Psychological Well-Being Scales (PWB), 42 Item version

Please indicate your degree of agreement (using a score ranging from 1-6) to the following sentences.

| | | Strongly disagree | | | | | Strongly agree |
|---|---|---|---|---|---|---|---|
| 1. | I am not afraid to voice my opinions, even when they are in opposition to the opinions of most people. | 1 | 2 | 3 | 4 | 5 | 6 |
| 2. | In general, I feel I am in charge of the situation in which I live. | 1 | 2 | 3 | 4 | 5 | 6 |
| 3. | I am not interested in activities that will expand my horizons. | 1 | 2 | 3 | 4 | 5 | 6 |
| 4. | Most people see me as loving and affectionate. | 1 | 2 | 3 | 4 | 5 | 6 |
| 5. | I live life one day at a time and don't really think about the future. | 1 | 2 | 3 | 4 | 5 | 6 |
| 6. | When I look at the story of my life, I am pleased with how things have turned out. | 1 | 2 | 3 | 4 | 5 | 6 |
| 7. | My decisions are not usually influenced by what everyone else is doing. | 1 | 2 | 3 | 4 | 5 | 6 |
| 8. | The demands of everyday life often get me down. | 1 | 2 | 3 | 4 | 5 | 6 |
| 9. | I think it is important to have new experiences that challenge how you think about yourself and the world. | 1 | 2 | 3 | 4 | 5 | 6 |
| 10. | Maintaining close relationships has been difficult and frustrating for me. | 1 | 2 | 3 | 4 | 5 | 6 |
| 11. | I have a sense of direction and purpose in life. | 1 | 2 | 3 | 4 | 5 | 6 |
| 12. | In general, I feel confident and positive about myself. | 1 | 2 | 3 | 4 | 5 | 6 |
| 13. | I tend to worry about what other people think of me. | 1 | 2 | 3 | 4 | 5 | 6 |
| 14. | I do not fit very well with the people and the community around me. | 1 | 2 | 3 | 4 | 5 | 6 |
| 15. | When I think about it, I haven't really improved much as a person over the years. | 1 | 2 | 3 | 4 | 5 | 6 |
| 16. | I often feel lonely because I have few close friends with whom to share my concerns. | 1 | 2 | 3 | 4 | 5 | 6 |
| 17. | My daily activities often seem trivial and unimportant to me. | 1 | 2 | 3 | 4 | 5 | 6 |
| 18. | I feel like many of the people I know have gotten more out of life than I have. | 1 | 2 | 3 | 4 | 5 | 6 |
| 19. | I tend to be influenced by people with strong opinions. | 1 | 2 | 3 | 4 | 5 | 6 |
| 20. | I am quite good at managing the many responsibilities of my daily life. | 1 | 2 | 3 | 4 | 5 | 6 |
| 21. | I have the sense that I have developed a lot as a person over time. | 1 | 2 | 3 | 4 | 5 | 6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 22. | I enjoy personal and mutual conversations with family members or friends. | 1 | 2 | 3 | 4 | 5 | 6 |
| 23. | I don't have a good sense of what it is I'm trying to accomplish in life. | 1 | 2 | 3 | 4 | 5 | 6 |
| 24. | I like most aspects of my personality. | 1 | 2 | 3 | 4 | 5 | 6 |
| 25. | I have confidence in my opinions, even if they are contrary to the general consensus. | 1 | 2 | 3 | 4 | 5 | 6 |
| 26. | I often feel overwhelmed by my responsibilities | 1 | 2 | 3 | 4 | 5 | 6 |
| 27. | I do not enjoy being in new situations that require me to change my old familiar ways of doing things. | 1 | 2 | 3 | 4 | 5 | 6 |
| 28. | People would describe me as a giving person, willing to share my time with others. | 1 | 2 | 3 | 4 | 5 | 6 |
| 29. | I enjoy making plans for the future and working to make them a reality. | 1 | 2 | 3 | 4 | 5 | 6 |
| 30. | In many ways, I feel disappointed about my achievements in life. | 1 | 2 | 3 | 4 | 5 | 6 |
| 31. | It's difficult for me to voice my own opinions on controversial matters. | 1 | 2 | 3 | 4 | 5 | 6 |
| 32. | I have difficulty arranging my life in a way that is satisfying to me. | 1 | 2 | 3 | 4 | 5 | 6 |
| 33. | For me, life has been a continuous process of learning, changing, and growth. | 1 | 2 | 3 | 4 | 5 | 6 |
| 34. | I have not experienced many warm and trusting relationships with others. | 1 | 2 | 3 | 4 | 5 | 6 |
| 35. | Some people wander aimlessly through life, but I am not one of them | 1 | 2 | 3 | 4 | 5 | 6 |
| 36. | My attitude about myself is probably not as positive as most people feel about themselves. | 1 | 2 | 3 | 4 | 5 | 6 |
| 37. | I judge myself by what I think is important, not by the values of what others think is important. | 1 | 2 | 3 | 4 | 5 | 6 |
| 38. | I have been able to build a home and a lifestyle for myself that is much to my liking. | 1 | 2 | 3 | 4 | 5 | 6 |
| 39. | I gave up trying to make big improvements or changes in my life a long time ago. | 1 | 2 | 3 | 4 | 5 | 6 |
| 40. | I know that I can trust my friends, and they know they can trust me. | 1 | 2 | 3 | 4 | 5 | 6 |
| 41. | I sometimes feel as if I've done all there is to do in life. | 1 | 2 | 3 | 4 | 5 | 6 |
| 42. | When I compare myself to friends and acquaintances, it makes me feel good about who I am. | 1 | 2 | 3 | 4 | 5 | 6 |

## 5. WHO-5 Well-being Index

**Psychiatric Research Unit**
WHO Collaborating Centre in Mental Health

# WHO (Five) Well-Being Index (1998 version)

Please indicate for each of the five statements which is closest to how you have been feeling over the last two weeks. Notice that higher numbers mean better well-being.

Example: If you have felt cheerful and in good spirits more than half of the time during the last two weeks, put a tick in the box with the number 3 in the upper right corner.

| | *Over the last two weeks* | All of the time | Most of the time | More than half of the time | Less than half of the time | Some of the time | At no time |
|---|---|---|---|---|---|---|---|
| **1** | **I have felt cheerful and in good spirits** | ☐5 | ☐4 | ☐3 | ☐2 | ☐1 | ☐0 |
| **2** | **I have felt calm and relaxed** | ☐5 | ☐4 | ☐3 | ☐2 | ☐1 | ☐0 |
| **3** | **I have felt active and vigorous** | ☐5 | ☐4 | ☐3 | ☐2 | ☐1 | ☐0 |
| **4** | **I woke up feeling fresh and re-sted** | ☐5 | ☐4 | ☐3 | ☐2 | ☐1 | ☐0 |
| **5** | **My daily life has been filled with things that interest me** | ☐5 | ☐4 | ☐3 | ☐2 | ☐1 | ☐0 |

## 6. PANAS - Positive and Negative Affect Schedule (PANAS-SF)

Positive and Negative Affect Schedule (PANAS-SF)

| Indicate the extent you have felt this way over the past week. | | Very slightly or not at all | A little | Moderately | Quite a bit | Extremely |
|---|---|---|---|---|---|---|
| PANAS 1 | Interested | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 2 | Distressed | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 3 | Excited | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 4 | Upset | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 5 | Strong | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 6 | Guilty | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 7 | Scared | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 8 | Hostile | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 9 | Enthusiastic | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 10 | Proud | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 11 | Irritable | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 12 | Alert | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 13 | Ashamed | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 14 | Inspired | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 15 | Nervous | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 16 | Determined | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 17 | Attentive | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 18 | Jittery | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 19 | Active | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |
| PANAS 20 | Afraid | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 |

## 7. The Flourishing Scale

# FLOURISHING SCALE



Below are 8 statements with which you may agree or disagree. Using the 1–7 scale below, indicate your agreement with each item by indicating that response for each statement.

- 7 - Strongly agree
- 6 - Agree
- 5 - Slightly agree
- 4 - Neither agree nor disagree
- 3 - Slightly disagree
- 2 - Disagree
- 1 - Strongly disagree

____ I lead a purposeful and meaningful life

____ My social relationships are supportive and rewarding

____ I am engaged and interested in my daily activities

____ I actively contribute to the happiness and well-being of others

____ I am competent and capable in the activities that are important to me

____ I am a good person and live a good life

____ I am optimistic about my future

____ People respect me

Scoring:

Add the responses, varying from 1 to 7, for all eight items. The possible range of scores is from 8 (lowest possible) to 56 (highest PWB possible). A high score represents a person with many psychological resources and strengths

## 8. Satisfaction with Life Scale

Below are five statements that you may agree or disagree with. Using the 1 - 7 scale below, indicate your agreement with each item by placing the appropriate number on the line preceding that item. Please be open and honest in your responding.

- 7 - Strongly agree
- 6 - Agree
- 5 - Slightly agree
- 4 - Neither agree nor disagree
- 3 - Slightly disagree
- 2 - Disagree
- 1 - Strongly disagree

____ In most ways my life is close to my ideal.

____ The conditions of my life are excellent.

____ I am satisfied with my life.

____ So far I have gotten the important things I want in life.

____ If I could live my life over, I would change almost nothing.

- 31 - 35 Extremely satisfied
- 26 - 30 Satisfied
- 21 - 25 Slightly satisfied
- 20 Neutral
- 15 - 19 Slightly dissatisfied
- 10 - 14 Dissatisfied
- 5 - 9 Extremely dissatisfied

## 9. Life Satisfaction Index: A (LSIA)

| | Response | | |
|---|---|---|---|
| **Item** | Agree | Disagree | Unsure |
| **1) As I grow older, things seem better than I thought they would.** | 1 | 0 | 0 |
| **2) I have gotten more of the breaks in life than most of the people I know.** | 1 | 0 | 0 |
| **3) This is the dreariest time of my life.** | 0 | 1 | 0 |
| **4) I am just as happy as when I was younger.** | 1 | 0 | 0 |
| **5) My life could be happier than it is now.** | 0 | 1 | 0 |
| **6) These are the best years of my life.** | 1 | 0 | 0 |
| **7) Most things I do are boring or monotonous.** | 0 | 1 | 0 |

| | | | |
|---|---|---|---|
| **8) I expect some interesting and pleasant things to happen to me in the future.** | 1 | 0 | 0 |
| **9) The things I do are as interesting to me as they ever were.** | 1 | 0 | 0 |
| **10) I feel old and somewhat tired.** | 0 | 1 | 0 |
| **11) I feel my age, but it does not bother me.** | 1 | 0 | 0 |
| **12) As I look back on my life, I am fairly well satisfied.** | 1 | 0 | 0 |
| **13) I would not change the past even if I could.** | 1 | 0 | 0 |
| **14) Compared to other people my age, I've made a lot of foolish decisions in my life.** | 0 | 1 | 0 |
| **15) Compared to other people my age, I make a good appearance.** | 1 | 0 | 0 |
| **16) I have made plans for things I'll be doing a month or a year from now.** | 1 | 0 | 0 |
| **17) When I think back over my life, I didn't get most of the important things I wanted.** | 0 | 1 | 0 |
| **18) Compared to other people, I get down in the dumps too often.** | 0 | 1 | 0 |
| **19) I've gotten pretty much what I expected out of life.** | 1 | 0 | 0 |
| **20) In spite of what some people say, the lot of the average man is getting worse, not better.** | 0 | 1 | 0 |

## 10. The Psychological General Well-Being Index-Revised Version

1. Did you feel in good spirits?† (DURING THE PAST WEEK)
2. Have you been bothered by any illness, bodily disorder, aches or pains?‡ (DURING THE PAST WEEK)
3. Have you felt depressed?† (DURING THE PAST WEEK)
4. Have you been in firm control of your behaviour, thoughts, emotions or feelings?‡ (DURING THE PAST WEEK)
5. Have you been bothered by nervousness or your 'nerves'?† (DURING THE PAST WEEK)
6. Did you have a lot of energy, pep or vitality?‡ (DURING THE PAST WEEK)
7. Have you felt downhearted and blue?† (DURING THE PAST WEEK)
8. Have you been generally tense or did you feel any tension?‡ (DURING THE PAST WEEK)
9. Have you been happy, satisfied, or pleased with your personal life?† (DURING THE PAST WEEK)
10. Did you feel healthy enough to carry out the things you like to do or had to do?‡ (DURING THE PAST WEEK)
11. Have you felt sad, discouraged, hopeless, or had so many problems that you wondered if anything was worthwhile?† (DURING THE PAST WEEK)
12. Have you been waking up feeling fresh and rested?‡ (DURING THE PAST WEEK)
13. Have you been concerned, worried or had any fears about your health?† (DURING THE PAST WEEK)
14. Have you had any reason to wonder if you were losing your mind, or losing control over the way you act, talk, think, feel or of your memory?‡ (DURING THE PAST WEEK)
15. Has your daily life been full or things that were interesting to you?† (DURING THE PAST WEEK)
16. Did you feel dull or sluggish?‡ (DURING THE PAST WEEK)
17. Have you been anxious, worried, or upset?† (DURING THE PAST WEEK)
18. Have you been feeling emotionally stable and sure of yourself?‡ (DURING THE PAST WEEK)
19. Did you feel relaxed and at ease?† (DURING THE PAST WEEK)
20. Have you felt cheerful and lighthearted?‡ (DURING THE PAST WEEK)

† Response options: None of the time; A little of the time; Some of the time; A good bit of the time; Most of the time; All of the time

‡ Response options: All of the time; Most of the time; A good bit of the time; Some of the time; A little of the time; None of the time

Scoring: Reverse items 3, 4, 5, 6, 7, 10, 11, 12, 13, 17, 18, 20, 21

Subscale composition: Anxiety — 5, 8, 17, 19, 22; Depressed Mood — 3, 7, 11; Positive Well-Being — 1, 9, 15, 20; Self-Control — 4, 14, 18; General Health — 2, 10, 13; Vitality — 6, 12, 21.

## 11. Bradburn's Affect Balance Scale – ABS

*Participants answer "Yes" or "No" to the following:*

Positive affect questions:

During the past few weeks (did you feel)…

Did you feel particularly excited or interested in something?

Proud because someone complimented you on something you had done?

Pleased about having accomplished something?

On top of the world?

That things were going your way?

Negative affect questions:

During the past few weeks (did you feel)…

Did you feel so restless that you couldn't sit long in a chair?

Very lonely or remote from other people?

Bored?

Depressed or very unhappy?

Upset because someone criticized you?

**Scoring:**

For positive affect, participants receive 1 point for every "Yes" they say. For negative affect, participants receive 1 point for every "Yes" they say. The overall "balance" score is created by subtracting the negative affect score from the positive affect score

## Scale of Positive and Negative Experience (SPANE)



Please think about what you have been doing and experiencing during the past four weeks. Then report how much you experienced each of the following feelings, using the scale below. For each item, select a number from 1 to 5, and indicate that number on your response sheet.

1. Very Rarely or Never
2. Rarely
3. Sometimes
4. Often
5. Very Often or Always

Positive
Negative
Good
Bad
Pleasant
Unpleasant
Happy
Sad
Afraid
Joyful
Angry
Contented

Scoring: The measure can be used to derive an overall affect balance score, but can also be divided into positive and negative feelings scales, and can be divided even further into general and specific feelings.

Positive Feelings (SPANE-P): Add the scores, varying from 1 to 5, for the six items: positive, good, pleasant, happy, joyful, and contented. The score can vary from 6 (lowest possible) to 30 (highest positive feelings score).

Negative Feelings (SPANE-N): Add the scores, varying from 1 to 5, for the six items: negative, bad, unpleasant, sad, afraid, and angry. The score can vary from 6 (lowest possible) to 30 (highest negative feelings score).

## 13. Mental Health Continuum Short Form (MHC-SF)

Adult MHC-SF (ages 18 or older)

Please answer the following questions are about how you have been feeling during the past month. Place a check mark in the box that best represents how often you have experienced or felt the following:

| During the past month, how often did you feel … | NEVER | ONCE OR TWICE | ABOUT ONCE A WEEK | ABOUT 2 OR 3 TIMES A WEEK | ALMOST EVERY DAY | EVERY DAY |
|---|---|---|---|---|---|---|
| 1. happy | | | | | | |
| 2. interested in life | | | | | | |
| 3. satisfied with life | | | | | | |
| 4. that you had something important to contribute to society | | | | | | |
| 5. that you belonged to a community (like a social group, or your neighborhood) | | | | | | |
| **SEE BELOW 6. that our society is a good place, or is becoming a better place, for all people** | | | | | | |
| 7. that people are basically good | | | | | | |
| 8. that the way our society works makes sense to you | | | | | | |
| 9. that you liked most parts of your personality | | | | | | |
| 10. good at managing the responsibilities of your daily life | | | | | | |
| 11. that you had warm and trusting relationships with others | | | | | | |
| 12. that you had experiences that challenged you to grow and become a better person | | | | | | |
| 13. confident to think or express your own ideas and opinions | | | | | | |
| 14. that your life has a sense of direction or meaning to it | | | | | | |

**Note: The original wording for item 6 was "that our society is becoming a better place for people like you." This item does not work in all cultural contexts. However, when validating the MHC-SF, test both versions of item 6 to see which one works best in your context.**

## 14. EQ-5D – 5L

Under each heading, please tick the **ONE** box that best describes your health **TODAY**

**MOBILITY**

I have no problems in walking about ☐
I have slight problems in walking about ☐
I have moderate problems in walking about ☐
I have severe problems in walking about ☐
I am unable to walk about ☐

**SELF-CARE**

I have no problems washing or dressing myself ☐
I have slight problems washing or dressing myself ☐
I have moderate problems washing or dressing myself ☐
I have severe problems washing or dressing myself ☐
I am unable to wash or dress myself ☐

**USUAL ACTIVITIES** *(e.g. work, study, housework, family or leisure activities)*

I have no problems doing my usual activities ☐
I have slight problems doing my usual activities ☐
I have moderate problems doing my usual activities ☐
I have severe problems doing my usual activities ☐
I am unable to do my usual activities ☐

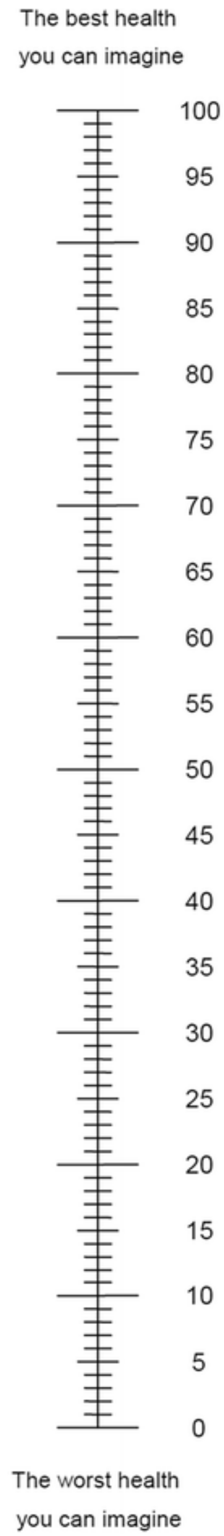
**PAIN / DISCOMFORT**

I have no pain or discomfort ☐
I have slight pain or discomfort ☐
I have moderate pain or discom ☐
I have severe pain or discomfort ☐
I have extreme pain or discomfort ☐

**ANXIETY / DEPRESSION**

I am not anxious or depressed ☐
I am slightly anxious or depressed ☐
I am moderately anxious or depressed ☐
I am severely anxious or depressed ☐
I am extremely anxious or depressed ☐

- We would like to know how good or bad your health is TODAY.
- This scale is numbered from 0 to 100.
- 100 means the best health you can imagine.
  0 means the worst health you can imagine.
- Mark an X on the scale to indicate how your health is TODAY.
- Now, please write the number you marked on the scale in the box below.




YOUR HEALTH TODAY = 

## 15. OPQOL - Older People's Quality of Life

Please indicates the extent to which you agree or disagree with each of the following statements *(5-point Likert response scale: Strongly agree to Strongly disagree)*

**Life overall**
1. I enjoy my life overall
2. I am happy much of the time
3. I look forward to things
4. Life gets me down

**Health**
5. I have a lot of physical energy
6. Pain affects my well-being
7. My health restricts me looking after myself or my home
8. I am healthy enough to get out and about

**Social relationships/leisure and social activities**
9. My family, friends or neighbours would help me if needed
10. I would like more companionship or contact with other people
11. I have someone who gives me love and affection
12. I'd like more people to enjoy life with
12a.I have my children around which is important *
29. I have social or leisure activities/hobbies that I enjoy doing
30. I try to stay involved with things
31. I do paid or unpaid work or activities that give me a role in life

**Independence, control over life, freedom**
13. I am healthy enough to have my independence
14. I can please myself what I do
15. The cost of things compared to my pension/income restricts my life
16. I have a lot of control over the important things in my life
32. I have responsibilities to others that restrict my social or leisure activities

**Home and neighbourhood**
17. I feel safe where I live
18. The local shops, services and facilities are good overall
19. I get pleasure from my home
20. I find my neighbourhood friendly

**Psychological and emotional well-being**
21. I take life as it comes and make the best of things
22. I feel lucky compared to most people
23. I tend to look on the bright side
24. If my health limits social/leisure activities, then I will compensate and find something else I can do

**Financial circumstances**
25. I have enough money to pay for household bills

26. I have enough money to pay for household repairs or help needed in the house
27. I can afford to buy what I want to
28. I cannot afford to do things I would enjoy

**Religion/culture**
33. Religion, belief or philosophy is important to my quality of life *
34 (35). Cultural/religious events/festivals are important to my quality of life *

*[Note: the 32 item version was used in QoL follow-up survey; a 35 item version was used in ONS Omnibus and Ethnibus surveys; three additional items were included after holding focus groups with ethnically diverse older people - marked with *]*

## 16. WHOQOL-OLD

| | | Not at all | A little | A moderate amount | Very much | An extreme amount |
|---|---|---|---|---|---|---|
| 1 (F25.1) | To what extent do impairments to your senses (e.g. hearing, vision, taste, smell, touch) affect your daily life? | 1 | 2 | 3 | 4 | 5 |
| 2 (F25.3) | To what extent does loss of, for example, hearing, vision, taste, smell or touch affect your ability to participate in activities? | 1 | 2 | 3 | 4 | 5 |
| 3 (F26.1) | How much freedom do you have to make your own decisions? | 1 | 2 | 3 | 4 | 5 |
| | | Not at all | Slightly | Moderately | Very much | Extremely |
| 4 (F26.2) | To what extent do you feel in control of your future? | 1 | 2 | 3 | 4 | 5 |
| 5 (F26.4) | How much do you feel that the people around you are respectful of your freedom? | 1 | 2 | 3 | 4 | 5 |
| | | Not at all | A little | A moderate amount | Very much | An extreme amount |
| 6 (F29.2) | How concerned are you about the way in which you will die? | 1 | 2 | 3 | 4 | 5 |
| | | Not at all | Slightly | Moderately | Very much | Extremely |
| 7 (F29.3) | How much are you afraid of not being able to control your death? | 1 | 2 | 3 | 4 | 5 |
| 8 (F29.4) | How scared are you of dying? | 1 | 2 | 3 | 4 | 5 |
| | | Not at all | A little | A moderate amount | Very much | An extreme amount |
| 9 (F29.5) | How much do you fear being in pain before you die? | 1 | 2 | 3 | 4 | 5 |
| | | Not at all | A little | Moderately | Mostly | Completely |
| 10 (F25.4) | To what extent do problems with your sensory functioning (e.g. hearing, vision, taste, smell, touch) affect your ability to interact with others? | 1 | 2 | 3 | 4 | 5 |
| 11 (F26.3) | To what extent are you able to do the things you'd like to do? | 1 | 2 | 3 | 4 | 5 |
| 12 (F27.3) | To what extent are you satisfied with your opportunities to continue achieving in life? | 1 | 2 | 3 | 4 | 5 |
| 13 (F27.4) | How much do you feel that you have received the recognition you deserve in life? | 1 | 2 | 3 | 4 | 5 |
| 14 (F28.4) | To what extent do you feel that you have enough to do each day? | 1 | 2 | 3 | 4 | 5 |
| | | Very dissatisfied | Dissatisfied | Neither satisfied nor dissatisfied | Satisfied | Very satisfied |
| 15 (F27.5) | How satisfied are you with what you have achieved in life? | 1 | 2 | 3 | 4 | 5 |
| 16 (F28.1) | How satisfied are you with the way you use your time? | 1 | 2 | 3 | 4 | 5 |
| 17 (F28.2) | How satisfied are you with your level of activity? | 1 | 2 | 3 | 4 | 5 |
| 18 (F28.7) | How satisfied are you with your opportunity to participate in community activities? | 1 | 2 | 3 | 4 | 5 |
| | | Very unhappy | Unhappy | Neither happy nor unhappy | Happy | Very happy |
| 19 (F27.1) | How happy are you with the things you are able to look forward to? | 1 | 2 | 3 | 4 | 5 |
| | | Very poor | Poor | Neither poor nor good | Good | Very good |
| 20 (F25.2) | How would you rate your sensory functioning (e.g. hearing, vision, taste, smell, touch)? | 1 | 2 | 3 | 4 | 5 |
| | | Not at all | A little | A moderate amount | Very much | An extreme amount |
| 21 (F30.2) | To what extent do you feel a sense of companionship in your life? | 1 | 2 | 3 | 4 | 5 |
| 22 (F30.3) | To what extent do you experience love in your life? | | | | | |
| | | Not at all | A little | Moderately | Mostly | Completely |
| 23 (F30.4) | To what extent do you have opportunities to love? | 1 | 2 | 3 | 4 | 5 |
| 24 (F30.7) | To what extent do you have opportunities to be loved? | | | | | |

## 17. CASP-19

| Domain | Items |
|---|---|
| Control | 1. My age prevents me from doing the things I would like to do |
| | 2. I feel that what happens to me is out of my control |
| | 3. I feel free to plan for the future |
| | 4. I feel left out of things |
| Autonomy | 5. I can do the things I want to do |
| | 6. Family responsibilities prevent me from doing the things I want to do |
| | 7. I feel that I can please myself what I do |
| | 8. My health stops me from doing the things I want to do |
| | 9. Shortage of money stops me from doing things I want to do |
| Pleasure | 10. I look forward to each day |
| | 11. I feel that my life has meaning |
| | 12. I enjoy the things that I do |
| | 13. I enjoy being in the company of others |
| | 14. On balance, I look back on my life with a sense of happiness |
| Self-realization | 15. I feel full of energy these days |
| | 16. I choose to do things that I have never done before |
| | 17. I feel satisfied with the way my life has turned out |
| | 18. I feel that life is full of opportunities |
| | 19. I feel that the future looks good for me |

Response options are ‘Often’, ‘Sometimes’, ‘Not often’, and ‘Never’. Positively worded items are scored 3–0 and negatively worded items (no. 1, 2, 4, 6, 8 and 9) are scored 0–3.

# APPENDIX B. REVIEWS

## 1. Factors related to MWB

### 1.1 The summarised findings from reviewed papers

| Author | Type | Method | Population | Age | Outcome variables | Primary explanatory variables | Covariates | Comparison | Results |
|---|---|---|---|---|---|---|---|---|---|
| Aghamolaei, T., et al. (2010) | Cross-sectional | Logistic regression | N=1000 (RR=94.5%) | 60-105 | **QoL** (MCS of SF-36) | **Age** | Gender, Education, Living Status, and Smoking Status | 60-75 vs. 75+ | **Age 75+** increase the risk to **Low QOL (OR= 1.58, 1.16~2.15, P<0.004)** |
| | | | | | | **Health** (CD) | | No CD vs. Have CD | **Have CD** increase the risk to **Low QOL (OR= 1.80, 1.1~2.99, P<0.03)** |
| Alpass, F., et al. (2000) | Cross-sectional | Hierarchical regression | N=217 (RR=72.3%) | 65+ | **PWB** (The Mental Health Inventory) | **Satisfaction with social supports and Job satisfactionn at retirement** | Demographic, PH | N/A (not mentioned) | Satisfaction with social supports (β =0.44, p<0.001) and job satisfactionn at retirement (β =0.128, p<0.05) were significantly and positively associated to PWB, and explained 22% of the variance in PWB scores. |
| Andrew, M. K., et al. (2012) | Cross-sectional (data used from longitudinal study) | Linear regression | N=5703 (Screening interview RR=87.8%; Repeat screening RR=63.3%) | 70=+ | **PWB** (Ryff scale) | **Frailty** (CSHA frailty index-include ADL/IADL limitations, health problems and CD) | Age, Gender, Education, MH (SF-36), and Cognition (3MS score) | N/A (not mentioned) | For each additional **frailty**-defining deficit, the **PWB** score **worsened by β =0.29, 0.22-0.36, p<0.001** |
| Balaswamy, S. and V. E. Richardson (2001) | Cross-sectional | Pearson's correlation coeffi | N=200 (RR=56.02%) | 60=+ | **PWB** (Bradburn's Affect Balance Scale) | **Personal resource variables** (mastery and self-esteem), **Life event variable** (Recent hospitalization), **Environment resource variables** (help from children, contact with siblings, contact with friends, and social interaction with neighbours) | Demographic (age, race, education, living arrangements, income, health, and time since widowhood), | | Demographics explained 14% of the variance, while hospitalization contributed another 3%. Widowers who had been hospitalized reported lower levels of well-being than those who had not been hospitalized. The personal and environmental resource variables explained the most variance (18%). Widowers who had more contact with friends and more interactions with neighbours had higher levels of well-being, but help from children was not significant. Although the environmental resources had the greatest impact on the total variance (33%), background characteristics, life event, and personal resources all contributed to the model. |
| Banjare, P., et al. (2015) | Cross-sectional | Multiple linear regression Hierarchical regression | N=310 (RR=97%) | 60+ | **LS** (Single subjective question) | **Cognitive health, Social support, Disability, and ADLs** | Age, Marital status, Education, Wealth, Economic dependence, Living arrangement, Health risk behaviours, and morbidity status | Males vs Females (separated analysis) | Better cognitive health (β M=0.327, p<0.01, β F=0.329, p<0.05), Social support (β M=0.286, β F=0.284, p<0.05) were significantly associated with higher LS. More **disability (β M=0.479, p<0.05, β F=0.476, p<0.01)** and **ADLs (β M=0.287, β F=0.288, p<0.01)** were **significantly** associated with **lower LS**. |
| Bowling, A. and Z. Gabriel (2007) | Mixed methods | QUAL Purposive interview | N=999 (RR=77%) | 65=+ | **QoL** (Self-rated QoL) | **Social relationships, Social roles and activities, Leisure activities enjoyed alone, Health, Psychological outlook and wellbeing, Home and neighbourhood, Financial circumstances, and Independence** | Other things such as society/politics/government policy (e.g. on immigration and pensions), ageism, use of technology, and animal welfare | N/A (not mentioned) | Themes that gave life quality: Social relationships (81%), Social roles and activities (60%), Leisure activities enjoyed alone (48%), Having health (44%), Psychological outlook and wellbeing (38%), Home and neighbourhood (37%), Financial circumstances (33%), and Independence(27%) |
| | | Logistic regression | | | | | | Self-rated Qol "good" vs. "not good" | The odds of rating QoL as good, compared to not good, were 1.887 (p=0.002) on those with more help/support, 3.440 (p=0.001) on those with better health, 2.521 (p=0.001) on those with less ADL disabilities, 1.702 (p=0.042) on those with better neighbourhood ratings, 2.143 (p=0.010) on those enjoyed living in the neighbourhood area, and 1.634 (p=0.023) on those with higher annual income. |
| Burns, R. A., et al. (2015) | Longitudinal | Generalized Estimating Equations (GEE) piecewise regression | N=652 (RR=11.1% on all 8 observations, RR=70% initially) | 65=+ | **SWB** (The Brief Positive and Negative Affect Measures) | **Widowhood** | Social demographic (Age and education) | Men vs. Women Pre-widow vs. Becoming widow vs. Post-widow | For both men **(β =-5.35, SE=1.02, p=0.007)** and women **(β =-4.71, SE=0.93, p<0.001)**, becoming widowed was strongly related to a strong **decline in positive affect** post partner's death. For both men and women there were higher levels of positive affect (men: β = 1.32, SE=0.48, p=0.006; women: β = 1.09, SE=0.43, p <0.012) immediately pre partner's death, and a decline in negative affect (men: β = −1.77, SE=0.61, p=0.004; women: β = −0.85, SE=0.31, p=0.005) post partner's loss. |
| Burton-Jeangros, C. and D. Zimmermann-Sloutskis (2016) | Longitudinal | Logistic marginal regression | N=1402 Generating 6387 observations RR not reported | 65-84 | **LS** (Single subjective question) | **Education and socio-economic resources, social integration (social support, living with a partner) and health** | Age, and cohort effect | Low level of covariates vs. High loevel of covariates | High education (b=0.27, SE=0.07, p<0.001), satisfaction with income (b=0.85, SE=0.04, p<0.001), high social support (b=0.14, SE=0.04, p<0.001), living with a partner (b=0.23, SE=0.06, p<0.001) and good self-perceived health (b=0.47, SE=0.04, p<0.001) were all positive and significant predictors of LS for women. |
| Chao, S.-F. (2012) | Longitudinal | Random effects Maximum likelihood | N=2856 Generating 6722 observations RR not reported | 60=+ | **LS** (Life Satisfaction Index A) | **IADL and Social support** | Social demographic (Age, gender, education, ethinicity, married status and numbers of children) | Sources of IADL support Sources of emotional support | **Prior IADL disability (B=-0.073, p<=0.001)** and **increasing IADL disablity (B=-0.116, P<=0.001)** all significantly associated with **lower LS**. Live with spouses (B=0.026, p<=0.001) and have more children (B=0.009, p<=0.001) and no instrumental support need (B=0.104, p<=0.001) all significantly associated with higher LS. Instrumental support from family members and formal organizations as well as emotional support from families, friends and formal organizations was significantly associated with better LS. Receiving instrumental support from sons (B=0.103, p<=0.001, β=0.136) and daughters-in-law (B=0.107, p<=0.001, β=0.117) yielded significant greater positive effects on LS than other sources, while receiving emotional support from sons (B=0.102, p<=0.001, β=0.151) and spouses (B=0.089, p<=0.001, β=0.145) yielded significant greater positive effects on LS than other sources. |

| Author | Type | Method | Population | Age | Outcome variables | Primary explanatory variables | Covariates | Comparison | Results |
|---|---|---|---|---|---|---|---|---|---|
| *Chiao, C., et al. (2012)* | *Cross-sectional* | *Multivariate regression* | *N=3602 (RR=81.64%) at baseline* | *60=+* | ***LS*** *(Life Satisfaction Index)* | ***Economic strain, SES, and PH (IADL, Nagi scale and CVD)*** | *Social demographic, survival status, waves of interview, baseline values of life satisfaction, psychological distress and self -rated health* | *N/A (not mentioned)* | ***Economic strain (B=-1.21, -1.31~-1.10, P<0.001), CVD (B=-0.19, -0.28~-0.09, P<0.001), IADL (B=-0.44, -0.55~-0.34, P<0.001)*** *and* ***Nagi scale (B=-0.28, -0.39~-0.17, P<0.001)*** *perceived* ***lower levels of LS****; being in* ***higher education (b=0.30, P<0.001) and income strata (b=0.16, P<0.05)*** *modestly* ***improved LS****.* |
| | *Longitudinal* | | *(N=829) (RR=23% of baseline sample size)* | | | | | *N/A (not mentioned)* | ***Economic strain (B=-0.72, -0.89~-0.55, P<0.001), IADL (-0.56, -0.72~-0.40, P<0.001)*** *and* ***Nagi scale (-0.37, -0.53~-0.20, P<0.001)*** *perceived* ***lower levels of LS****; being in* ***higher education (b=0.77, P<0.001)****modestly* ***improved LS****.* |
| *Cooper, C., et al. (2011)* | *Cross-sectional* | *Multivariate regression* | *N=2672 RR not reported* | *60-69* | ***Happiness*** *(Single subjective question)* | ***Married Status, ADL dependency, Primary work group size, Having qualification, Religious attendce, AUDIT score (Alcohol)*** | *Gender, ethinicity, home ownership, social capital, social participation* | *60-69 vs. 60-* | ***Being married (b=0.51, SE=0.14, p<0.001)*** *was significantly* ***positively predict happniess*** *for older people age 60-69 compared with younger people under 60.* |
| | | | | *70-79* | | | | *70-79 vs. 60-* | ***Being married (b=0.58, SE=0.16, p<0.001), having less ADL dependency (b=0.11, SE=0.05, p=0.026), drink less alcohol (b=0.05, SE=0.02, p=0.009)*** *were significantly* ***positively predict happniess*** *for older people age 70-79 compared with younger people under 60.* |
| | | | | *80+* | | | | *80+ vs. 60-* | ***Having less ADL dependency (b=0.19, SE=0.07, p=0.004), having qualifications (b=0.52, SE=0.20, p=0.012), religious attendance (b=0.20, SE=0.07, p=0.002)*** *were significantly* ***positively predict happniess*** *for older people age 80+ compared with younger people under 60.* |
| *Cooper et al. (2014)* | *Cohort Study; (Meta-analysis for comparing results only)* | *Equivalent linear regression Random-effect meta-analysis* | *N=3096 for three studies with WEMWBS* | *53 (MWB were taken at age 60-64) to 82 years at baseline (RR not reported)* | ***MWB*** *(WEMWBS)* | ***Physical capability*** | *Age, sex* | *Different Cohorts Different measurs of physical capability* | *Estimates from meta-analyses of age and sex-adjusted unstandardized regression coefficients ranged from a mean difference in WEMWBS score of +0.79 (0.28, 1.30) to +1.70 (0.49, 2.91) for every 1SD increase in physical capability.* |
| *de Belvis, A. G., et al. (2008a)* | *Cross-sectional* | *Logistic regressions* | *N=33744 (RR=86.6%)* | *60=+* | ***QoL*** *(SF-12 Mental)* | ***Socio-demographic*** *(age, gender),* ***Geographical area, Educational level****, S****elf-assessment of household-income****, L****ifestyle*** *(tobacco use, physical activity),* ***Medical conditions, Occurrence of disease during the previous four weeks****, R****educed autonomy because of chronic diseases, Access to health-care services, Medical consultation during the past four weeks*** | *N/A (not mentioned)* | *N/A (not mentioned)* | *Being females, reported lower household income, spent less time in recreational and religious activities, lived too far from their relatives and had few relationships with friends and relatives and those living in the South rather than in the North West of Italy, were significantly less likely to have an MCS above the median value. The analysis also demonstrated a poorer MCS in respondents with more chronic diseases and occurrence of disease during the previous 4 weeks.* |
| *de Belvis, A. G., et al. (2008b)* | *Cross-sectional* | *Logistic regressions* | *N=1601 (RR not reported)* | *60=+* | ***QoL*** *(SF-12 Mental)* | ***Social relationships*** *(marital status; living alone; frequency of visiting/seeing relatives; frequency of visiting/seeing friends; and excessive mean distance between own and relatives' homes)* | *Socio-demographic (age, gender, educational level, size of town, self-assessment of household-income, marital status, living alone), Lifestyle (tobacco use, physical activity, use of leisure time for recreational or religious activities), Self-reported health status and disability (chronic diseases, occurrence of disease during the previous 4 weeks, reduced autonomy because of chronic diseases)* | *N/A (not mentioned)* | *Older people aged 75 years or more were 32% less likely than subjects aged 60–74 years to have an MSC above the median value. Those who reported a lower household income were significantly less likely to have an MSC above the median value. Elderly subjects with one or more chronic diseases were more likely to have poorer mental health scores in HRQL compared with subjects without chronic disease. The occurrence of disease in the last 4 weeks was 50% likely to be associated with an MSC above the median value. Elderly subjects with reduced autonomy due to chronic disease were 38% ('sometimes') and 69% ('often') less likely to have MSC scores above the median value.* |
| *de Souto Barreto (2014)* | *Cross-sectional* | *Multinomial logistic regressions Structural equation modelling (SEM)* | *S=323 (reponse to wave 3, 34.8% from 928 sampling) N=317 (98.1% of 323 response to wave 3)* | *63-96* | ***Happiness*** *(Single subjective question)* | ***PA*** | *SF* | *Happiness Little/none of the time vs. some of the time vs. most of the time vs. all of the time* | ***Social functioning (0.38) significant (+) directly*** *associated to happiness* |
| | | | | | | | *Physical decline, CD, Chronic pain* | | *Physical decline, CD, Chronic pain were* ***significant (-)indirectly*** *linked to happiness* |
| | | | | | | | *Total volume of PA* | | ***PA (0.25) was significant (+) indirectly*** *linked to happiness;* <br> *Higher the total volume of PA, higher the probability of having higher levels of happiness, even adjust demographic and health-related variables. However, the relationship no longer significant when SF was entered.* |
| *Elliott et al. (2014)* | *Mixed Methods-Explanatory Design Cohort (NSHD + HCS)* | *Linear regression* | *Nquant=2731 (NSHD RR=76% and HCS RR=88%)* | *Mean NSHD=63.5 (SD=0.74)* | ***MWB*** *(WEMWBS)* | ***Neighbourhood cohesion*** | *SES, paid employment/doing regular voluntary work, illness or disability, mobility problems, housing tenure, SS, social participation, and the personality traits emotional stability and extraversion* | *NSHD Cohort* | ***Neighbourhood cohesion*** *was* ***siganificant (+) r=0.31, p<0.001*** *associated with* ***MWB*** <br> *1SD increase in neighbourhood cohesion, MWB increased by* ***+1.86 (1.47, 2.25) 95%CI*** |
| | | | | *Mean HCS=73.2 (SD=2.47)* | | | | *HCS Cohort* | ***Neighbourhood cohesion*** *was* ***siganificant (+) r=0.41, p<0.001*** *associated with* ***MWB*** <br> *1SD increase in neighbourhood cohesion, MWB increased by* ***+1.77 (1.42, 2.12) 95%CI*** |
| | | *QUAL Semi-structured qualitative interview* | *Nqual=60 (HCS 30 +NSHD 30)* | *N/A* | | | | *Age cohorts* | *Very few cohort members made an explicit link between their sense of belonging to their community and their wellbeing. Some common themes in the responses of those with high neighbourhood cohesion scores provided possible explanations (eg. social involvement and social support) for the links between cohesion and wellbeing. Age was a moderator of the association between neighbourhood cohesion and wellbeing, with neighbourhood cohesion more strongly associated with wellbeing at older ages.* |
| *Fisher, K. and F. Li (2004)* | *RCT* | *Mean slop modelling* | *N=582 RR not reported (Initial RR=30.5%)* | *65=+* | ***LS*** *(SWLS)* | ***PA (Walking)*** | *Social demographic (neighbourhood level and individual level)* | *Walking vs. Control* | *The* ***mean slope for SF–12 Mental scores (M = 1.24)*** *was statistically* ***significant (p < .001) for walking group****, whereas the mean slope for the control neighborhoods was not (M= 0.26, p = .10).* |
| | | | | | ***QoL*** *(SF-12 Mental)* | | | | ***The mean slope*** *was* ***significant*** *for the* ***intervention neighborhoods (M= 0.14, p < .001)****, but not significant in the control neighborhoods (M = 0.013, p = .33)* |
| *Fox et al. (2007)* | *Mixed Methods-Explanatory Design Focus group* | *Quant: Pearson zero-order correlation analysis* | *N=176, RR=86.3% (64/79 controls and 112/125 intervention at baseline) (40/79 controls and 92/125 interventions at completion) N=24 interviewees* | *70+* | ***WB and QoL*** *(LS, general WB, QoL, SWB, and physical self-perceptions)* | ***PA and sedentary living*** *daily PA energy expenditure (PAEE), light intensity per day (LPA), moderate intensity per day (MVPA), and sedentary minutes per day (SED)* | *N/A (not mentioned)* | *PAEE vs. LPA vs. MVPA vs. SED* | ***PAEE*** *were* ***weakly (r = 0.17–0.24)*** *but consistently related to WB and QoL. PH produce stronger coeffcients. LS and general WB scales produced the weakest correlations.* <br> ***LPA*** *was* ***not related*** *to any of the WB and Qol measures.* <br> ***SED*** *produced* ***negative (-)*** *correlations with several psychological health indicators.* <br> ***MVPA*** *was* ***small (+)*** *but was also related to QoL subscales* |
| | | *Qual: purposively selected semi-structured interviews Interpretive phenomenological analysis (Smith and Osborn 2003)* | | | | | | | ***Physical and mental benefits*** ***(+)*** *were experienced and arose from attendance in the group exercise sessions.* <br> *Enjoyable, fun, high quality social interactions, a sense of improved physical competence, a worthwhile effort, positive reactions from family and friends.* |

| Author | Type | Method | Population | Age | Outcome variables | Primary explanatory variables | Covariates | Comparison | Results |
|---|---|---|---|---|---|---|---|---|---|
| Frazier, C., et al. (2005) | Cross-sectional | Canonical Correlation Analysis | N=86<br>(RR=93.5% of participants; RR=29.2% of total recruited) | 65-89 | **PWB**<br>**(Scales of PWB )** | **Multidimensional Measure of Religious Involvement** | Demographic (gender, age, ethnic group, socioeconomic status (SES), marital status, educational background, town of residence, religious denomination, and health status) | N/A<br>(not mentioned) | Several dimensions of religious involvement (Organizational, Nonorganizational, and Subjective) were associated with several dimensions of psychological well-being (Positive Relations with Others, Self-Acceptance, Environmental Mastery, Purpose in Life, and Personal Growth) |
| Gabriel, Z. and A. Bowling (2004) | Qualitative study | Purposive interview | N=80 Interviewed sample<br>(RR=75.5%)<br><br>P=999 Survey population<br>(RR=77%) | 65=+ | **QoL**<br>(Perception of QoL) | **Social relationships, Social roles and activities, Other activities enjoyed alone, Health, Psychological wellbeing, Home and neighbourhood, Financial circumstances, and Independence** | Other things | N/A<br>(not mentioned) | Good things that gave life quality: **Social relationships (96%), Social roles and activities (80%), Other activities enjoyed alone (93%), Having health (85%), Psychological wellbeing (96%), Home and neighbourhood (96%), Financial circumstances (73%), and Independence(69%)** |
| Gale, C. R., et al. (2011) | Cross-sectional<br>(HCS Cohort) | Multivariate regression | N=1157<br>(RR=82% on MWB questions) | Mean age=73.2<br>(SD=2.47) | **MWB** (WEMWBS) | **Neighbourhood deprivation, cohesion and problems** | Social class, income, presence of limiting long-term illness or disability, problems with mobility, the personality trait emotional stability and perceived social support | N/A<br>(not mentioned) | 1SD increase in **neighbourhood cohesion, MWB increased by +1.99 (1.63, 2.34) p<0.001.** 1SD increase in **social support, MWB increased by +1.69 (1.33, 2.05) p<0.001.** 1SD increase in **emotional stability, MWB increased by +3.62 (3.26, 3.98) p<0.001.** The relation between a SD increase in neighbourhood problem score and lower mental wellbeing was not statistically significant. |
| Gautam, R., et al. (2007). | Cross-sectional | Standard multiple regression | N=489<br>(RR=34.8%) | 60=+ | **LS**<br>(SWLS) | **Leisure and religious activity** | Sociodemographic (age, gender, marital status, education), Financial satisfaction, Self reported general health , and Social support | Men vs. Women | Separate regression models for gender identified **socializing with others (B = 1.22; p = 0.038)** to be a significant correlate **for men**, while **visiting friends (B = 1.29; p = 0.009), socializing with others (B = 1.45; p =0.005), and watching television and listening to the radio (B = 0.92; p = 0.016)** emerged as significant correlates for **women**. |
| Golden, J., et al. (2009) | Cross-sectional | OR | N=1334<br>(RR not reported) | 65=+ | **QoL**<br>(Self-rated QoL) | **Social network** | Age and gender, depression, physical disability and cognitive impairment | N/A<br>(not mentioned) | **One-tertile increase in social engagement domain** subscales associated with **good self-rated QoL (OR=1.5, 1.3–1.7, p<0.001) and being happy or very happy (OR=1.3, 1.1–1.5, p<0.001), and life worth living (OR=1.4, 1.1–1.8, p=0.003)**, the family subscales did not show significant association. |
| Gouveia, É. R. Q., et al. (2017) | Cross-sectional | Standard multiple regression | N=802<br>(RR not reported) | 60-79 | **QoL**<br>(SF-36) | **PA, Functional fitness and body composition** | Health (history of depression and falls during the last year) and demographic information (age, living alone) | N/A<br>(not mentioned) | **Body strength (aerobic endurance)** showed a **positive** relation of **β = 0.19 (p < 0.001)**on **SF-36 mental component** and **living alone** emerged to be the strongest **negative** predico**r β = −0.20 (p < 0.001)**. |
| Gow, A. J., et al. (2007) | Cohort Study | Standard regression | N=488<br>(RR=87.5%) | 79 | **LS**<br>(SWLS) | **SOS (Significant others scale), Household composition, Loneliness** | Age-11 IQ and Age-79 IQ, sex, years of education, and social class | Men vs. Women | The largest contribution on SWLS came from **loneliness (B=-2.11, SE=0.26, β = –0.35, p <0.001, about 12% of the variance)**, followed by **having someone to talk about problems (B=6.16, SE=1.46, β = 0.18, p <0.001, about 6% of the variance)**, and **average support (B=0.20, SE=0.06, β = 0.14, p <0.01)** discrepancy accounting for about **2% of the variance.** Compare women and men, loneliness remained the greatest proportion of variance in SWLS. |
| Greenfield, E. A. and N. F. Marks (2004) | Cross-sectional | Multivariate regression | N=373<br>(RR=60.8%) | 65-74 | **PWB**<br>(Negative and positive affect, and purpose in life) | **Major role-identity absences score, Volunteer status** | Age, race, gender, income, education, and functional health limitations | N/A<br>(not mentioned) | More **major role identity absences** were associated with **more negative affect (b=0.70, p<=0.01)**, **less positive affect (b= -0.65, p<=0.05)**, and **less purpose in life (b= -0.50, p<=0.05)**. Having more **functional limits** were associated with **more negative affect (b=0.70, p<=0.001)**, **less positive affect (b= -0.84, p<=0.001)**, and **less purpose in life (b= -0.43, p<=0.05)**. **Being a volunteer** was a predictor of **more positive affect (b=0.88, p<=.05)**. The effect of **major role-identity absences (b=1.05, p<=0.05)** on respondents' feelings of purpose in life is contingent upon whether or not they volunteer. |
| Heo, J., et al. (2015) | Cross-sectional | Structural equation model | N=5203<br>(RR not reported) | 65-105 | **LS**<br>(SWLS)<br><br>**PWB**<br>(Ryff scale) | **Internet use, Social support, Loneliness** | N/A<br>(not mentioned) | N/A<br>(not mentioned) | **Loneliness** was found to have significant path coefficients toward both **life satisfaction (β =-0.489, SE=0.040, t = - 13.993, p<0.001)** and **psychological well-being (β =-0.411, SE=0.033, t = - 12.864, p<0.001)**. **Internet use significantly indirect** predicted **LS (β =0.007, SE=0.001, t = 7.0, p<0.01)** and **PWB (β =0.005, SE=0.001, t =5.0, p<0.01)** through social support and loneliness. |
| Huxhold, O., et al. (2013) | Longitudinal | Dual-change score models in a structural equation modeling framework | N=667<br>(RR=32.8% of the baseline sample size) | 65=+ | **LS**<br>(SWLS)<br><br>**EWB**<br>(Positive and Negative Affect Schedule) | **Network variables** | Age, Sex, socioeconomic status (SES) | N/A<br>(not mentioned) | **Increases in social engagement** were **positively** associated with **changes in positive affect (β = 0.23, p=0.000)** as well as **changes in life satisfaction (β = 0.19, p=0.000)** |
| Jang, Y., et al. (2006) | Cross-sectional | Hierarchical regression | N=255<br>(RR=60.1%) | 60-84 | **LS**<br>(Life Satisfaction Index Z) | **Religiosity, Adherence to African American culture** | Demographic (age, gender, marital status, and education), Self-rated health | More traditional group vs. Less traditional group | Background variables explained 19% of the variance in LS, with **married status (B=1.25, t=2.27, p<0.05)**, **higher education (B = 0.19, t=1.94, p<0.05)**, and **better health status (B =1.76, t=5.12, p<0.001)** constituting significant predictors of **greater life satisfaction**. **Religiosity (B = 0.42, t=2.75, p<0.01)** and adherence to African American culture explained an additional 5% of the variance. **The interaction term (B = 0.01, t=2.19, p<0.05)** of religiosity and adherence to African American culture explained an additional 2% of the variance.<br>The impact of religiosity on LS was found to be **stronger in the more traditional group** (B = .77, p < .01) compared to that in the less traditional group (B = .44, p < .05). |
| Ju, Y. J., et al. (2016) | Longitudinal | Generalized Estimating Equations (GEE) | N=3274<br>(baseline sample size, RR not reported) | 65=+ | **QoL**<br>(Single-item scale rating) | **Relationship satisfaction with adult offspring, Regular financial aid from adult offspring, Household income and wealth** | age, gender, education level, marital status, employment status, health status (perceived health status and limitation on daily activities), health behavior (smoking and alcohol consumption), total number of chronic medical conditions, depressive symptoms, social factor (frequency of contact with neighbors), and living with children or not | N/A<br>(not mentioned) | Participants who had a highly unsatisfying relationship with offspring had a QoL score of -21.93 (SE = 0.55; P < 0.0001). Individuals who did not receive regular financial aid from their offspring had a QoL of -0.92 (SE = 0.38; P = 0.0171) compared with those who received regular financial aid from their offspring. In addition, low education level, marital status, low income or level of wealth, health status perceived as being unhealthy, depressive symptoms, greater number of chronic diseases, and reduced frequency of contact with neighbor were associated with a lower QoL. |

| Author | Type | Method | Population | Age | Outcome variables | Primary explanatory variables | Covariates | Comparison | Results |
|---|---|---|---|---|---|---|---|---|---|
| Kadowaki, L., et al. (2015) | Cross-sectional | Hierarchical regression (OLS regression) | N=3244 (RR=19.8%) | 65=+ | **LS** (SWLS) | **Home Care Needs** | Age, sex, marital status, visible minority status, education, income, functional impairments, number of chronic conditions, and social support | N/A (not mentioned) | Overall, health factors explained the most variance (10.9%) in life satisfaction, followed by social support (6.6%) and home care needs (3.4%). Home care needs met (β = 0.08, p < 0.001, SE = 0.22) had a weak positive relationship with LS. Weak positive association between being female (β = 0.05, p < 0.01, SE = 0.22), and for those aged 75–84 (β = 0.15, p < 0.001, SE = 0.23), and the 85 and older age group (β = 0.27, p < 0.001, SE = 0.27) with life satisfaction (compared to the 65–74 age group). Those who were unmarried (β = –0.05, p < 0.01, SE = 0.22) expressing lower levels of LS. Completion of post-secondary education (β = 0.05, p <0 .01, SE = 0.24)had a very weak positive relationship. Number of chronic conditions (β = –0.19, p < 0.001, SE = 0.04) showed a moderate negative relationship. Mild functional impairment (β = –0.12, p < 0.001, SE = 0.24), moderate functional impairment (β = –0.17, p < 0.001, SE = 0.30), severe functional impairment (β = –0.21, p < 0.001, SE = 0.43), and total functional impairment (β = –0.15, p < 0.001, SE = 0.44), all resulted in moderate negative relationships with LS in comparison to those with no impairment. Social support in the form of positive social support (β = 0.27, p < 0.001, SE = 0.03) had a moderate positive relationship with LS. |
| Kahana, E., et al. (2013) | Longitudinal | Ordinal logistic regression | N=585 (RR=58.5%) | 72-98 | **PWB** (Negative and positive affect, SWLS and depression) | **Altruistic attitudes, Frequency of volunteering, Informal helping behavior** | Demographic characteristic (gender, age, and marital status), Driving status, Chronic illness, Functional limitations | N/A (not mentioned) | Altruistic attitudes (β = 0.465, p < 0.05, SE = 0.2), hours of volunteering (β = 0.042, p < 0.05, SE = 0.021), and informal helping (β = 0.401, p < 0.01, SE = 0.145) statistically significantly predicted positive affect at Wave 5. Respondents who were younger (β = -0.066, p < 0.001, SE = 0.02) and had fewer functional limitations (β = -0.528, p < 0.05, SE = 0.221) had higher degrees of positive affect. Positive affect at Wave 2 (β = 1.082, p < 0.001, SE = 0.115) significantly predicted positive affect at Wave 5.<br>Hours of volunteering (β = 0.061, p < 0.05, SE = 0.026), and informal helping (β = 0.368, p < 0.05, SE = 0.177) statistically significantly predicted LS at Wave 5. Respondents who had fewer functional limitations (β = -0.685, p < 0.01, SE = 0.251), had fewer chronic illness (β = -0.202, p < 0.01, SE = 0.077) had higher degrees of LS. LS at Wave 2 (β = 1.458, p < 0.001, SE = 0.164) significantly predicted LS at Wave 5. |
| Kirchmann, H., et al. (2013) | Cross-sectional | Multiple linear regression | N=81 (RR=33.2%) | 69-73 | **LS** (Life Satisfaction Index) | **Attachment, Medical burden, Coping with deficits and losses in later life** | sociodemographic and psychosocial characteristics (e.g., age, gender, education, income, marital status, former occupational status, relationship status, having a pet) and socioeconomic status | N/A (not mentioned) | Attachment (AAPR) security (b=0.222, SE=0.105, P=0.019) was significant positively associated to LS, Cumulative illness (CIRS) (b=-0.327, SE=0.100, P<0.001) was significant negatively associated to LS. |
| Kobayashi, E., et al. (2015) | Longitudinal | Unstandardized and Standardized Path Coefficients | N=4917 observations RR from 54%-74% for each waves | 60-92 | **LS** (Life Satisfaction Index A) | **Social networks** (marital status, co-residence with a child/children, and frequency of contact with non-co-resident children) | Age, employment status, financial status, and functional health (ADLs, IADLs or other physical activities) | Men vs. Women<br>Early cohort vs. Later cohort | Being married and LS have a stronger positive association among later cohorts than earlier cohorts for men (1.291, p<0.001; and 1.109, p<0.001) but not for women;<br>Co-residence with a child and LS have a stronger positive association among earlier cohorts than later cohorts for women (0.492, p<0.05; 0.477, p<0.001; and 0.567, p<0.001) but not for men.<br>The cohort different do not support nonfamily contact and LS association.<br>Positive association among financial status and LS were consistant over age cohort for both men and women;<br>Negative association among functional limitations and LS were consistant over age cohort for both men and women. |
| Lee, Y.-J. and W.-L. Hung (2011) | Cross-sectional | Regression analysis | N=352 (RR=88%) | 60=+ | **WB** (General Well-Being) | **Exercise intensity, Exercise frequency, Exercise participation level** | Demographic (gender, age, marital status, and living arrangement) | N/A (not mentioned) | Exercise frequency had a significantly positive effect on well-being ( b=0.13, p<0.01), and on dimensions 'depression (b=0.12, p<0.05)', 'positive well-being ( b=0.18, p<0.01)', and 'vitality ( b=0.18, p<0.001)'. In contrast, it was found that exercise intensity had a significantly negative effect on wellbeing (b=-0.22, p<0.001), and on all the six dimensions. |
| Levin, J. S., et al. (1996) | Longitudinal | Panel analysis | N=111 (RR=29.6%) | 65-80 | **PWB** (LSI & positive affect) | **Religious attendance** | Age, gender, education, marital status, employment status, and subjective health | N/A (not mentioned) | Cross-sectional: T1 religious attendance exerted statistically significant positive effects on T1 LS, but only on the oldest (0.28, p<0.01) and middle generation, not the youngest. T2 religious attendance exerted statistically significant positive effects on T2 LS, but only on the olderst (0.14, p<0.05) and middle generation, not the youngest. T1 religious attendance did not affect T2 LS.Religious attendance did not affect positive afffect. |
| Li, S., et al. (2012) | Cross-sectional | Multiple linear regression | N=2342 (RR=98.9%, 0.8% of the total population in Xicheng district) | 60-80 | **Happiness** (MUNSH) | **Social Support Rating Scale (SSRS), Self-rating Anxiety Scale (SAS), Self-rating Depression Scale (SDS)** | gender, age, education, income, marital status, and family relationships | N/A (not mentioned) | The self-reported level of depression (B = -0.328, p < 0.001, SE = 0.020), selfreported level of anxiety (B = -0.205, p < 0.001, SE = 0.024), poor family relationships (B = -1.707, p < 0.001, SE = 0.415), and poor self-regulation of emotion (B = -1.011, p < 0.001, SE = 0.278), were negatively associated with the overall self-reported level of happiness. Social support (B = 0.194, p < 0.001, SE = 0.025), income level (B =0.764, p < 0.001, SE = 0.182), regular exercise (B =1.214, p = 0.001, SE = 0.363), retiring at the governmentmandated age (B = 0.999, p =0.014, SE = 0.405) and the number of leisure activities (B = 0.656, p=0.039, SE = 0.317) were positively associated with the overall self-reported level of happiness. |
| Lim, H. J., et al. (2017) | Longitudinal | Latent class growth modeling and logistic regression | N=1954 (RR=55.6% of baseline) | 65=+ | **LS** (5 domains: health, finance, housing, neighbour relationships, and family relationships) | **sex, age, education, marital status, residential area, number of members in the household, household composition type, housing type, current physical and mental health status, private health insurance, household income, and household expense** | N/A (not mentioned) | High-stable LS vs. others | Individuals in the high LS trajectory group were more likely to have higher education, good physical health, and good mental health than those in all other trajectory groups. Financial adequacy was a significant predictor for high LS trajectory, compared with all other groups except the improving LS group.<br>The individuals in the low-stable group were older than those in the upper middle-stable or improving group and more likely to be in poorer physical and mental health, living alone and be more financially stressed than those in the upper middlestable or high trajectory groups.<br>upper middle-stable group was noted to be younger than the low stable group and less likely to live in a rural area than an urban one (OR = 0.47, 95% CI: 0.33–0.66). Middle-stable trajectory group was also less likely to live in a rural area than an urban one (OR = 0.75, 95% CI: 0.62, 0.91). |
| López García, E., et al. (2005) | Cross-sectional | Multiple linear regression | N=3600 (RR=63.9%) | 60=+ | **QoL** (SF-36 spanish) | **Socio-demographic variables** (sex, age, educational level and size of town of residence), **lifestyle** (tobacco use, alcohol consumption and physical activity during leisure time) | N/A (not mentioned) | N/A (not mentioned) | A rise in the educational level (b=6.0, P<0.01) and size of town of residence (b=5.5, P<0.001) were accompanied by a rise in SF-36 mental. Moderate alcohol consumption (b=3.2, p<0.01) was associated with better SF-36 mental than either abstinence or high consumption. Physical activity during leisure time (moderate: b=3.3, p<0.001; regular/intense: b=9.7, p<0.001) was associated with the better the SF-36 mental. Chronic disease (b=-7.9, p<0.001), having Osteoarthritis (b=-3.5, p<0.001), being a woman (b=-10.3, p<0.001) were accompanied by a decrease in SF-36 mental. |
| | | | | | | **Social networks (marital status, co-residence with a child/children, and frequency of contact with non-co-resident children)** | Socio-demographic variables (sex, age, educational level and size of town of residence), **lifestyle** (tobacco use, alcohol consumption and physical activity during leisure time) | N/A (not mentioned) | Unmarried (b=-3.4, p<0.01), having Osteoarthritis (b=-3.4, p<0.001), seldom or never seen family (b=-3.5, p<0.05) were accompanied by a decrease in SF-36 mental. |
| Lowis, M. J., et al. (2011) | Cross-sectional | Step-wise multiple regression | N=121 (RR=74.5%) | 60-98 | **QoL** (LS: CAS-14) | **Self-rated health, Retirement adjustment, Retirement stress** | Age, sex, living arrangements (alone, with partner, with other or others), and whether the respondent has care responsibility for another person | N/A (not mentioned) | Self-rated health (b=0.321, p<0.001), retirement adjustment (b=0.443, p<0.001) and retirement stress (b=0.224, p<0.001) each predicting the criterion of CAS-14. |

| Author | Type | Method | Population | Age | Outcome variables | Primary explanatory variables | Covariates | Comparison | Results |
|---|---|---|---|---|---|---|---|---|---|
| Margelisch, K., et al. (2017) | Longitudinal | Hierarchical regression | N=252<br>(RR=67% of baseline) | 60-89 | **LS**<br>(SWLS) | **Marital satisfaction, Subjective health, Enduring vulnerabilities, Adaptive behaviour** (psychological resilience)**, Stressful events, Socio-demographic variables** (age, gender, education, and self-declared financial situation) | N/A<br>(not mentioned) | N/A<br>(not mentioned) | Unhappily married group (B=-0.316, p<0.001) initially accounted for 9.6% of the variance in LS. In the final model, higher levels of LS were best predicted by higher values of resilience (B=0.269, p<0.001) and less relationship stress (B=-0.229, p<0.001), followed by not unhappily married (B=-0.180, p<0.01), a good financial situation (B=-0.169, p<0.01) and good health of the partner (B=-0.155, p<0.05). The final model explained 30% of the variance in life satisfaction. |
| Markides, K. S. and D. J. Lee (1990) | Longitudinal | Residualized change regression | N=254<br>(RR=50% of baseline) | 60=+ | **LS**<br>(Life Satisfaction Index) | **Functional health, Self-rated health, Psychological distress, Level of activity, Sociodemographic predictors** (Age, Gender, Ethnicity, Marital Status and Education) | N/A<br>(not mentioned) | N/A<br>(not mentioned) | The only significant predictor of life satisfaction change was Time 1 psychological distress. Subjects with higher distress (β = -0.146, p<0.05) were more likely to experience declines in life satisfaction. |
| McAuley, E., et al. (2000) | RCT | Latent growth curve methodology | N=174<br>(Missing data on dependent variables and independent varibles) | 60-75 | **Happiness**<br>(MUNSH)<br><br>**LS**<br>(SWLS) | **Exercise frequency, Social support** | Demographics and health and physical activity history | 6-mths program vs. 6-12 mths follow-up | Individuals who exercised more often during the program also realized greater increases in LS over the 6-month program (β = 0.30, P<0.05) and significantly smaller declines in LS over the follow-up period 6-12 mths (β = -0.24, P<0.05).<br>Increases in social support during the exercise program were related to improvements in LS over this period (β = 0.19, P<0.05) and to smaller declines at follow-up (β = -0.22, P<0.05).<br>No significant changes on happiness. |
| Merz, E.-M. and N. S. Consedine (2009) | Cross-sectional | Hierarchical regression | N=1118<br>(RR not reported) | 65-86 | **Well-being**<br>(Differential Emotions Scale) | **Emotional support, Instrumental support, and Attachment dimensional scores** | Demographic variables (age, sex, place of birth, self-reported ethnicity, education, marital status, number of children, and household size) and functional impairment scores | N/A<br>(not mentioned) | Of the control variables, positive wellbeing was positively associated with older age (β =0.08, SE=0.03, p<0.01), higher education (β =0.15, SE=0.03, p<0.001), and being African Caribbean (β =0.16, SE=0.03, p<0.001)or African American (β =0.19, SE=0.03, p<0.001) but was negatively related to functional impairment (β =-0.20, SE=0.03, p<0.001) and being Eastern European (β =-0.13, SE=0.03, p<0.001).<br>Emotional support (β =0.09, SE=0.01, p<0.01) was positively related to wellbeing whereas receiving instrumental support from the family network (β =-0.06, SE=0.03, p<0.05) was negatively related to wellbeing. After adding the attachment dimensions to the model, however, the support effects disappeared. Higher scores on the secure (β =0.15, SE=0.03, p<0.001) and dismissive attachment (β =0.13, SE=0.03, p<0.001) dimension were positively related to wellbeing, whereas higher scores on ambivalent/fearful attachment (β =-0.26, SE=0.03, p<0.001) were negatively associated with wellbeing. |
| Merz, E.-M. and O. Huxhold (2010) | Cross-sectional | Multivariate regression | N=1146<br>(RR not reported) | 65=+ | **SWB**<br>(PANAS items for Positive and Negative Affect) | **Instrumental support, Quality of the relationshipand the interaction of both factors on well-being** | Sex, subjective health and functional health, partnership quality, and emotional support from kin | Did vs. did not receive instrumental support from kin | Wellbeing was significantly associated with partnership satisfaction (F=30.34 p=0.000), subjective health (F=24.74, p=0.000), and functional health (F=9.79, p=0.000). The main effect of receiving instrumental support from kin was not significant. Significant interaction between instrumental support from kin and relationship quality with kin (F=4.06, p=0.018) on well-being. |
| | | | | | | | Sex, subjective health and functional health, partnership quality, and emotional support from non-kin | Did vs. did not receive instrumental support from non-kin | Wellbeing was significantly associated with partnership satisfaction (F=18.74 p=0.000), subjective health (F=23.17, p=0.000), and functional health (F=7.36, p=0.001). The main effect of receiving instrumental support from non-kin (F=3.61, p=0.027) was was also significant on well-being. |
| Momtaz, Y. A., et al. (2010) | Cross-sectional | Multiple hierarchical regression | N=1367<br>(RR=81.3%) | 60-110 | **PWB**<br>(WHO-5 Well being Index) | **Widowhood, Religiosity Scale and Physical Health** | Socioeconomic status (SES) | N/A<br>(not mentioned) | Widowhood (B=-8.47, SE=1.2, t=-7.08, p<0.01) was statistically and negatively associated with PWB. When taking religiosity into account, the affect of widowhood on PWB became insignificant. Younger age (B=-0.55, SE=0.09, t=-6.42, p<0.01), better physical health (B=-1.95, SE=0.42, t=-4.64, p<0.01), personal (B=1.14, SE=0.15, t=7.88, p<0.01) and social religiosity (B=0.51, SE=0.18, t=2.83, p<0.01) were associated with higher levels of PWB. |
| Momtaz, Y. A., et al. (2016) | Cross-sectional | Multiple logistic regression | N=2202<br>(RR=87.6%) | 60=+ | **SWB**<br>(Flourishing scale) | **Mental status** (GDS)**, Health status** (CD)**, Socio-demographic** (age, gender, marital status, educational attainment, living arrangement, and stratum) | N/A<br>(not mentioned) | N/A<br>(not mentioned) | Male (AOR = 1.31; 95% CI: 1.07–1.61, p < .01), employed (AOR = 1.49; 95% CI: 1.20-1.85, p<.001), having living children (AOR = 1.05; 95% CI: 1.02–1.09, p<.01) are significantly associated with flourishing. For level of education, compared with no-formal education group, the primary (AOR = 1.38; 95% CI: 1.09–1.75, p < .01) and the secondary/tertiary (AOR = 1.78; 95% CI: 1.30–2.42, p < .001) had higher odds of flourishing. In addition, having three and more chronic medical conditions compared with older adults without chronic medical conditions significantly decreased flourishing (AOR = 0.76; 95% CI: .60–.96, p < .05). |
| Ng, S. T., et al. (2017) | Cross-sectional | Logistic regression | N=6530<br>(RR not reported) | 80=+ | **LS**<br>(Single subjective question) | **Socio-demographic characteristics, economic, health related, activity participation, family and community factors, IADL index, Living arrangement and availability of social services** | N/A<br>(not mentioned) | N/A<br>(not mentioned) | Being a male (b=-0.308, SE=0.0667, p<0.001), more schooling years (b=0.027, SE=0.0108, p<0.05), City (b=0.374, SE=0.0830, p<0.001) residence, very good self-rated health (b=3.806, SE=0.1379, p<0.001), higher MMSE (b=0.025, SE=0.0050, p<0.001), more IADL (b=-0.053, SE=0.0118, p<0.001), having regular physical examination (b=0.263, SE=0.0652, p<0.001), better perceived economic status (b=2.259, SE=0.1088, p<0.001), number of social security and commercialized insurances owned (b=0.094, SE=0.0421, p<0.05), living with family (b=0.407, SE=0.0726, p<0.001), and number of social services available in the community (b=0.082, SE=0.0177, p<0.001) are significant determinants of LS. |
| Ní Mhaoláin, A. M., et al. (2012) | Cross-sectional | Multivariate model (Stepwise hierarchical linear regression) | N=466<br>(RR=34.5%) | 65=+ | **LS**<br>(Life Satisfaction Index A) | **Personality** (extroversion–introversion and neuroticism-stability), **Mood and PWB**, **Physical Health** (Cognition, Comorbidity, Lawton IADL Scale (0 low function to 8 high function), PA) | Gender, Social class, Widowed/separated, Currently driving, Age, Education (age left school) | N/A<br>(not mentioned) | Being depressed (B=−2.23, SE=0.612, p <0.001), feelings of loneliness (B=−0.782, SE=0.214, p <0.001), reporting higher levels of subjective exhaustion (B=−0.919, SE=0.474, p = 0.045), underlying personality traits of extroversion (B=0.126, SE=046, p = 0.005) or neuroticism (B=−0.182, SE=0.041, p<0.001), recent participation in PA (B=1.13, SE=0.458, p = 0.005), in an advance age (B=0.075, SE=0.032, p = 0.020) were the independent determinants of LS<br>IADL function has no significant effect on multivariate model. |
| Okabayashi, H., et al. (2004) | Cross-sectional | Standardized Regression | N=1299 for those with spouse and children<br>(RR=96.3%) | 60=+ | **LS**<br>(Life Satisfaction Index A) | **Social support and Negative relations** | Age, gender, educational attainment, and physical health | Network with spouse and children vs. Network with children only | Among older Japanese with a spouse, social support from the spouse (b=0.23, p<0.001), children (b=0.12, p<0.05), and others (b=0.13, p<0.05) all had a significant and positive effect on LS.<br>Physical health (b=0.55, p<0.0001) also had a significant and positive effect on LS. Negative relations did not have significant affect. |
| | | | N=677 for those with children only<br>(RR=91.2%) | | | | | | Among older Japanese without a spouse, only social support from children (b=0.32, p<0.001) had a significant and positive effect on LS.<br>Physical health (b=0.61, p<0.0001) also had a significant and positive effect on LS. Negative relations did not have significant affect. |
| Olsson, L. A., et al. (2014) | Cross-sectional | General linear model | N=389<br>(RR not reported) | 74±5 years | **Positive WB**<br>(Psychological General Well-Being) | **PA** | Age, Biomakers (BMI, systolic BP, HDL, LDL, ApoAI, ApoB, ApoB/AI, and CRP) | N/A<br>(not mentioned) | There was significant relationship between physical activity (b=0.194, p<0.01) and the subdimension of positive WB. Revealed stronger and more positive relationships between physical activity and PGWB in females (b=0.251, p<0.001) than in males. |
| Park, J., et al. (2012) | Cross-sectional | Structural equation model | N=200<br>(RR=96.6%) | 65=+ | **LS**<br>(SWLS) | **Religiosity and Social support** | Demographic and socioeconomic variables (age, gender, education, self-rated health, annual income, and marital status) | N/A<br>(not mentioned) | The direct effect of religiosity on LS was significant (standardized regression coefficient β = 0.21, p = 0.002).<br>Social support partially mediated the relationship between religiosity and LS. Social support was predicted by religiosity (β = 0.20, p = 0.005) and predicted LS by (β = 0.22, p < 0.001).<br>Religiosity and social support accounted for 31% of the variance in LS.<br>Age (β = 0.14, p = 0.026), health (β = 0.29, p < 0.001), and income (β = 0.15, p = 0.018) were positively associated with LS. |

| Author | Type | Method | Population | Age | Outcome variables | Primary explanatory variables | Covariates | Comparison | Results |
|---|---|---|---|---|---|---|---|---|---|
| Park, M., et al. (2014) | Cross-sectional | Hierarchical regression | N=2356<br>(RR not reported) | 65=+ | **LS**<br>(Single subjective question) | **Mental health, Physical health, and Social health componenta** | Demographic variables (age, education level, and economic status) | N/A<br>(not mentioned) | Factors that statistically significant affect LS: relationship with children (B=0.525, β = 0.515, p < 0.001); self-rated health (B=3.867, β = 0.167, p < 0.001); depression (B= -0.786, β = -0.116, p < 0.001); participation in social activities (B=2.155, β = 0.077, p < 0.001); number of family members (B=0.960, β = 0.073, p < 0.001); education (B=1.848, β = 0.054, p < 0.01); and beneficiary status (B= -3.835, β = -0.045, p < 0.05). This model contributed to explain 48.65% of the total variance. |
| Shin, S. H. and S. R. Sok (2012) | Cross-sectional | Multiple regression | N=300<br>(RR=88.2%) | 65=+ | **LS**<br>(The Standard Life Satisfaction Instrument) | **Perceived health status, Self-esteem, Depression and Demographic characteristics (gender, age, religion, educational level and monthly allowance)** | N/A<br>(not mentioned) | Living with family vs. Living alone | The major factors influencing LS were shown to be depression (B=-1.218, SE=0.140, b=-0.532, p=0.003), perceived health status (B=-1.342, SE=0.146, b= 0.454, p=0.002), self-esteem (B=-0.514, SE=0.078, b= 0.362, p=0.001), monthly allowance (B=0.243, SE=0.031,b= 0.198, p=0.002) and age (B=-0.103, SE=0.023, b=-0.158, p=0.002) for the older people living with family; and perceived health status (B=-1.518, SE=0.126, b= 0.502, p=0.001), depression (B=-1.124, SE=0.043,b=-0.454, p=0.002), self-esteem (b= 0.397), monthly allowance (b= 0.294) and age (b=-0.132) for the older people living alone. |
| Silverstein, M., et al. (2006) | Cross-sectional | Hierarchical regression (Unstandardized OLS Regression) | N=1561<br>(RR=86.7%) | 60=+ | **LS**<br>(SWLS) | **Intergenerational living arrangements (coresidence and proximity) and Intergenerational support (providing and receiving financial transfers, instrumental support, and emotional cohesion)** | Sociodemographic control variables (age, income, health status, gender, education, occupation, and marital status) | N/A<br>(not mentioned) | Having less functional health difficulties (b=-0.085, p<0.001) and more children (b=0.175, p<0.001) tended to increase life satisfaction. Respondents living with both children and grandchildren (b=0.655, p<0.001) and respondents living with grandchildren only (b=0.400, p<0.05) had greater life satisfaction than did those in a network-family structure. When taken intergenerational support into account, the whole model lost its significance. |
| Stathi, A., et al. (2002) | Qualitative study | One-on-one interview<br>Group interview | N=28<br>(RR not reported) | 62-81 | **SWB**<br>(5 dimensions: developmental, material, physical, mental, and social well-being) | **PA** | N/A<br>(not mentioned) | N/A<br>(not mentioned) | PA contribute to all dimensions of SWB except material well-being. It contribute to mental health of older adults through maintenance of a busy and active life, mental alertness, positive attitude toward life and avoidance of stress, negative function, and isolation. |
| Sun, W., et al. (2015) | Cross-sectional | General linear model | N=3714<br>(RR=78.5%) | 65=+ | **QoL**<br>(SF-36 Mental) | **Health status, Behavioral factors, Social–psychological factors** | Demographic characteristics (age, sex, ethnicity, marital status, living arrangement, education, health insurance, and pension) | N/A<br>(not mentioned) | Better MCS was significantly associated with no chronic disease (b=0.231, p<0.01), good sleeping quality (b=0.179, p<0.01), taking a walk more than 3-4 times a week (b=0.149, p<0.01), good visual ability (b=0.109, p<0.01), being marital (b=0.108, p<0.01), ethnicity Han (b=-0.085, p<0.01), good filial piety (b=0.105, p<0.01), regular diet (b=0.063, p<0.01), has alcohol consumption (b=0.053, p<0.01), never smoke (b=0.036, p<0.05). |
| Sun, X., et al. (2017) | Cross-sectional | Generalised linear regression | N=975<br>(RR=0.05% of the population) | 60-75 | **QoL**<br>(SF-36 Mental) | **Social capital** | Age, gender, education, occupation before 60 years old, annual family income per capita, living arrangement, county and presence/absence of chronic illness | Men vs. Women | Higher annual family income per capita (b=2, SE=0.88, p = 0.02) and living in Liangshan (b=2.58, SE=1.17, p = 0.03) were associated with higher MCS score in men. Each increased point in problem-solving resources was associated with an increase of b=1.58 (SE=0.53, p < 0.01) points of MCS in men.<br>Having chronic illness (b=-3.75, SE=1.07, p < 0.01) was associated with lower MCS score in women. Each increased point in domestic resources (b=1.34, SE=0.44, p < 0.01) and problem-solving resources (b=1.32, SE=0.57, p < 0.05) were associated with an increase of MCS in women. |
| Tajvar, M., et al. (2008) | Cross-sectional | Multiple logistic regression | N=400<br>(RR not reported) | 65=+ | **QoL**<br>(SF-36 Mental Iranian) | **Sex, age, education, living status, marital and economic status** | N/A<br>(not mentioned) | N/A<br>(not mentioned) | Only sex (Female OR=2.48, 1.5~4.12, p<0.0001) and economic status (Intermediate OR=2.26, 1.06~4.81, p=0.03; Poor OR=4.85, 2.18~10.8, p<0.0001) were significant determinants of older people's poor MCS. |
| Thanakwang, K., et al. (2012) | Cross-sectional | Structural equation model | N=469<br>(RR not reported) | 60=+ | **PWB**<br>(harmony, interdependence, respect, acceptance, and enjoyment) | **Social networks and Social support** | Age, gender, education, income, physcial functioning (ADL), and marital status | N/A<br>(not mentioned) | Family support ( b=0.45, SE=0.06, p<0.001) and friendship support ( b=0.17, SE=0.06, p<0.01) were all directly associated with PWB. However, family networks had only indirect influence on PWB through family support (b=0.12, p<0.01), and so as friendship networks through friendship support (b=0.12, p<0.01). Friendship networks also had an indirect effect on PWB through family support (b=0.19, p<0.001). |
| Vagetti, G. C., et al. (2015) | Cross-sectional | OLS | N=1806<br>(RR=95.3%) | 60-93 | **QoL**<br>(WHOQOL-BREF & WHOQOL-OLD) | **PA** (International Physical Activity Questionnaire) | Sociodemographic (age, race/ethnicity, marital status, occupation, education, and economic class) and medical conditions (body mass index, blood pressure, health problems, and regularly-used drugs) | High volume of PA vs. Low<br>High frequency of PA vs. low | Older women who reported a high volume of MVPA (more than 150 min/week) had a 74% (OR=1.74, 1.2~2.53, p<0.01) greater chance of having a higher score on the Overall QOL and 62% (OR=1.62, 1.18~2.21, p<0.01) greater chance of having a higher score on the General score of the WHOQOL-OLD.<br>Older women who reported a weekly volume of light walking of at least 150 min were 59% (OR=1.59, 1.16~2.19, p<0.01) and 38% (OR=1.38, 1.05~1.81, p<0.05) more likely to present a higher Overall QOL score and a higher General score on the WHOQOL-OLD, respectively.<br>Subjects who reported higher frequencies of MVPA and light walking were also more likely to have higher Overall QoL scores and WHOQOL-OLD. |
| Van Hoecke, A. S., et al. (2014) | RCT | Hierarchical pairwise regression | N=422 at 10-week follow-up<br>(RR=95.5% of baseline)<br>N=348 at 1-year follow-up<br>(RR=78.7% of baseline)<br>N=344 at 2-year follow-up<br>(RR=77.8% of baseline) | 60=+ | **SWB**<br>(Louvain Well-Being Scale) | **PA**<br>(referral group, walking group and 10-week physical activity coaching group) | Age, gender, marital status, and self-rated health status | Baseline vs. 10-week follow-up vs. 1-year follow-up vs. 2-year follow-up | Increased PA contributed to an increased level of well-being from pretests to 10-week follow-up (b=0.114, p<0.05) and from pretest to 1-year follow-up(b=0.199, p<0.001), but not on changes after 2-year follow-up.<br>Perceived need-support of the coach after the intervention additionally contributed to changes in wellbeing from pretest to 10-week follow-up (b=0.143, p<0.0) and from pretest to 1-year follow-up (b=0.122, p<0.05). |
| Waddell, E. L. and J. M. Jacobs-Lawson (2010) | Cross-sectional | Gender-based regression | N=800<br>(RR not reported) | 60-101 | **Positive well-being** | **Background** (age, marital status, education, income, self-rated health)**, Psychological** (importance of religion, depression)**, and Social** (social interaction, volunteer work) | N/A<br>(not mentioned) | Men vs. Women | Men who were not married (B=-0.57, SE=0.26, b=-0.10, p < 0.05), have worse health status (B=-0.50, SE=0.14, b=-0.18, p < 0.01), and have more depressive symptoms (B=-0.49, SE=0.07, b=-0.38, p < 0.01) was associated with lower positive well-being ratings. Together, these three variables accounted for 32% of the variability in positive well-being for men.<br>For women, increased age (B=-0.04, SE=0.02, b=-0.11, p < 0.05) was associated with declines in positive well-being. Having worse health status (B=-0.50, SE=0.14, b=-0.17, p < 0.01), and have more depressive symptoms (B=-0.55, SE=0.07, b=-0.39, p < 0.01) was associated with lower positive well-being ratings. Women who rated religion less important (B=-0.3, SE=0.09, b=-0.14, p < 0.01) and those who reported not participate in volunteer work (B=-0.19, SE=0.08, b=-0.11, p < 0.05) had lower positive well-being. Combined, these variables explained 35% ofthe variance in women's positive well-being. |

| Author | Type | Method | Population | Age | Outcome variables | Primary explanatory variables | Covariates | Comparison | Results |
|---|---|---|---|---|---|---|---|---|---|
| Ye, M. and Y. Chen (2014) | Cross-sectional | OLS | N=939<br>(RR not reported) | 60=+ | **WB**<br>(3 positive items in the Chinese version of the Geriatric Depression Scale) | **Household living arrangement and Neighborhood identity** | Demographic (age, gender, marital status, education, income and self-rated health) | Living arrangements | Compared to 'living alone,' 'living with spouse only' (B=0.36, p<=0.05) and 'living with children only' (B=0.54, p<=0.05) were positively associated with elders' well-being. After controlling for demographic features, only 'living with children only' (B=0.47, p<=0.01) was still positively related to elders' well-being, but 'living with spouse only' was no longer significant.<br>The sense of belonging (B=0.91, p<=0.001) and the sense of pride toward the neighborhood (B=0.80, p<=0.001) were positively associated with elders' well-being. |
| Yoon, D. P. and E.-K. O. Lee (2007) | Cross-sectional | Hierarchical multiple regression | N=215<br>(RR not reported) | 60-92 | **LS**<br>(SWLS) | **Religiousness/Spirituality** (daily spiritual experiences, values/ beliefs, forgiveness, private religious practice, religious/spiritual coping, and religious support), **and Social support** | Demographic (age, ethnicity, education, annual income, and living arrangement) | N/A<br>(not mentioned) | Higher levels of LS were significantly associated with having more religious and spiritual coping skills (beta = 0.18, p < 0.05), receiving greater religious support (beta = 0.15, p < 0.05), and receiving more social support (beta = 0.36, p < 0.001). |
| Zimmer, Z. and H.-S. Lin (1996) | Cross-sectional | OLS | N=4049<br>(RR=92%) | 60=+ | **WB**<br>(Index of WB) | **Leisure activity** | Demographic (age, education, marital status, and income), health status and social network | Men vs. Women | Physical (F=0.12, p<0.01)and contemplative (F=-0.09, p<0.01) activities, display significant relationships with WB for women, and only physical activity (M=0.15, p<0.01) for men.<br>WB was significantly influenced by health status for both men and women on: number of health conditions (M=-0.16, F=-0.01, p<0.01), ADL difficulties (M=-0.14, F=-0.16, p<0.01), and Self-rated health (M=-0.26, F=-0.27, p<0.01). Both social network variables, size of household (M=0.10, F=0.08, p<0.01) and satisfaction with contact (M=0.15, F=0.24, p<0.01), were significantly related to well-being, however, the latter variable was an extremely strong predictor for women. As well, income (M=0.11, F=0.09, p<0.01) displayed positive associations for both genders.<br>Married men (M=0.11, p<0.01) displayed higher WB scores, where marital status was insignificant for women. Conversely, women seemed to benefit from higher education (F=0.08, p<0.01), while for men, education had no influence. Finally, age was significant for men (M=0.09, p<0.01). |

Note: **SEff**, Self-efficacy; **LS**, Life satisfaction; **WB**, Well-being; **QoL**, Quality of life; **GH**, Self-rated general health; **PA**, physical activity; **CD**, Chronic diseases; **WEMWBS**, Warwick-Edinburgh Mental Wellbeing Scale; **WMB**, Mental well-being; **CS**, Cognitive status; **SE**, Self-esteem; **MH**, Mental health; **SF**, Social functioning; **PWB**, Psychological well-being; **SWB**, Subjective well-being; **ADL**, Activities of daily living; **IADL**, Instrumental activities of daily living; **SD**, Social demographics; **MS**, Marital status; **BP**, Blood pressure; **SS**, social support; **SES**, socialeconomics status; **PH**, physical health; **Quant**, Quantitative; **Qual**, Qualitative;

## 1.2 Quality Assessment Methods

| **Study Design** | **Quality Assessment Tool** | **Quality Rating of study** |
|---|---|---|
| *Cross-Sectional* | Newcastle Ottawa Scale, NOS | Score 0-10<br><br>Selection (Max 5*)<br>Comparability (Max 2*)<br>Outcome (Max 3*) |
| *Cohort Study* | Newcastle Ottawa Scale, NOS | Score 0-9<br><br>Selection (Max 4*)<br>Comparability (Max 2*)<br>Outcome (Max 3*) |
| *Longitudinal Study* | Newcastle Ottawa Scale, NOS | Score 0-9<br><br>Selection (Max 4*)<br>Comparability (Max 2*)<br>Outcome (Max 3*) |
| *Qualitative Study* | National CASP Appraisal Tool | Score 1-10<br><br>1-3 (High risk)<br>4-7 (Moderate risk)<br>8-10 (Low risk) |
| *RCT* | National CASP Appraisal Tool | Score 1-11<br><br>1-3 (High risk)<br>4-7 (Moderate risk)<br>8-11 (Low risk) |
| *Mixed Methods* | MMAT Checklist | Score 0-13<br><br>Scores varying from 25% (*) - one criterion met to 100% (****) - all criteria met |

## 1.3 Quality Assessment Results

| Paper | Type | Population and Response Rate (RR) | Bias | Risk | Limitation | QA | Selection | Comparability | Outcome | Exclude |
|---|---|---|---|---|---|---|---|---|---|---|
| Aghamolaei, T., et al. (2010) | Cross-sectional | N=1000 (RR=94.5%) | Reporting bias | Moderate | Only odd ratio as result. Very weak power on reporting association between determinants and MWB. | **NOS 6/10** | 3 | 2 | 1 | |
| Alpass, F., et al. (2000) | Cross-sectional | N=217 (RR=72.3%) | Selection bias | Moderate | Only men participants obtained via a non-probability convenience sample drawn from support networks. Paticipants were from one NewZealand Low city. | **NOS 5/10** | 2 | 2 | 1 | |
| Andrew, M. K., et al. (2012) | Cross-sectional (data used from longitudinal study) | N=5703<br>(Screening interview RR=87.8%; Repeat screening RR=63.3%) | Attrition bias<br>Reporting bias | Moderate | Association was assessed using cross-sectional data in second screening, no clude why the RR droped.;<br>No data discription over the two screening. | **NOS 7/10** | 3 | 2 | 2 | |
| Balaswamy, S. and V. E. Richardson (2001) | Cross-sectional | N=200<br>(RR=56.02%) | Selection bias<br>Attrition bias<br>Reporting bias | High | Local widowers whose wives died within 12 months period. However, interview were taken one year later and varied by the time.<br>251/357 were eligible to participate; 200/251 were interviewed. The refused to be interviewed may have differed from the participants in various ways: lacked energy due to intense or complicated grieving, valued their privacy, or been too busy or depressed.<br>Wrong results, no source for the results. | **NOS 2/10** | 1 | 0 | 1 | X |
| Banjare, P., et al. (2015) | Cross-sectional | N=310<br>(RR=97%) | Selection bias<br>Measurement bias | Moderate | 89.7% of the participants reported at least 1 morbidities;<br>Single question of LS might have measurement bias. | **NOS 6/10** | 3 | 2 | 1 | |
| Bowling, A. and Z. Gabriel (2007) | Mixed methods | N=999<br>(RR=77%) | Selection bias<br>Reporting bias | Moderate | 82% male and 76% female rated their Qol as at least "good", the remain 18% male and 24% female rated their QoL as "not good". The QoL sample was skewed towards the positive end of the scale;<br>Only odd ratio as result for the quantitative study. Very weak power on reporting association between determinants and MWB. | **MMAT 9/13** | QUAL 4/4 | QUANT 2/4 | MIXED 3/5 | |
| Burns, R. A., et al. (2015) | Longitudinal | N=652 (RR=70%) | Attrition bias | Moderate | Missing data on the observation time for the participants. Only 11.1% provide all 8 observations. | **NOS 6/9** | 3 | 2 | 1 | |
| Burton-Jeangros, C. and D. Zimmermann-Sloutskis (2016) | Longitudinal | N=1402<br>Generating 6387 observations<br>RR not reported | Selection bias<br>Reporting bias<br>Measurement bias | High | Only women participants;<br>The interpretation of the logistic marginal regression estimates represents the association between a change in the binary LS outcome (OR) and a change in the covariate at the population level;<br>There is a significant difference in LS between cohorts of identical ages, with earlier cohorts being more satisfied than more recent cohorts. This study analyses did not adjust for those covariates migh lead LS bias.<br>Single subjective question on LS as the measure. | **NOS 4/9** | 2 | 1 | 1 | |
| Chao, S.-F. (2012) | Longitudinal | N=2856<br>Generating 6722 observations<br>RR not reported | Attrition bias | Moderate | Missing data on the observation time for the participants. The surveys were conducted inconsistantly every three or four years. | **NOS 5/9** | 2 | 2 | 1 | |
| Chiao, C., et al. (2012) | Cross-sectional<br>Longitudinal | N=3602 (RR=81.64%) at baseline<br>(N=829)<br>(RR=23% of baseline sample size) | Selection bias<br>Attrition bias | Moderate | Survivors had significant higher levels for well-being;<br>Missing data on the longitudinal study for the participants. Only 23% (N=829) left for longitudinal analysis. | **NOS 5/9** | 2 | 2 | 1 | |
| Cooper, C., et al. (2011) | Cross-sectional | N=2672<br>RR not reported | Selection bias<br>Attrition bias<br>Measurement bias | High | General population study with separate analysis for younger people with older people. However, there is no comparison over the three identified older age groups;<br>Missing data on response rate for the participants;<br>Single subjective question on happiness as the measure. | **NOS 4/10** | 1 | 1 | 2 | |
| Cooper et al. (2014) | Cohort Study;<br>(Meta-analysis for comparing results only) | N=3096 for three studies with WEMWBS<br>RR not reported | Attrition bias | Moderate | Missing data on covariates;<br>Collection of the WEMWBS was coordinated across each of the studies and the individual study teams took responsibility for their data collections. No relevant information with the response rate for the WEMWBS. | **NOS 6/9** | 2 | 2 | 2 | |
| De Belvis, A. G., et al. (2008a) | Cross-sectional | N=33744 (RR=86.6%) | Reporting bias | Moderate | Only odd ratio as result. No analysis on the association between determinants and MWB. | **NOS 6/10** | 4 | 1 | 1 | X |
| De Belvis, A. G., et al. (2008b) | Cross-sectional | N=1601<br>(RR not reported) | Selection bias<br>Attrition bias<br>Reporting bias | High | Samples from one region only, and 69.9% of the sample reported had been diagnosed with one or more chronic diseases by their GP, and 41.6% had suffered from diseases or health problems in the previous 4 weeks.<br>No RR for the regional participantion.<br>Only odd ratio as result. Very weak power on reporting association between determinants and MWB. The link between social relationship and SF-12 was only supported for physical components. | **NOS 4/10** | 2 | 1 | 1 | X |
| de Souto Barreto (2014) | Cross-sectional | N=317 (98.1% of 323 response to wave 3)<br>S=323 (reponse to wave 3, 34.8% from 928 sampling) | Selection bias<br>Attrition bias<br>Measurement bias<br>Reporting bias | Moderate | The participants were members of the medical insurance of the FNES - not representative of the socio-professional diversity found in France;<br>Low response rate (34.8%), which may have bias because respondents are probably healthier than non-respondents;<br>No other potential determinants of subjects' happiness - confounders in the associations between PA and happiness;<br>Single subjective question on happiness as the measure;<br>No report on the CI or SE and SD of the coefficient of MWB determinants | **NOS 5/10** | 2 | 2 | **1** | |
| Elliott et al. (2014) | Mixed Methods-Explanatory Design<br>Cohort (NSHD + HCS) | Nquant=2731 (NSHD RR=76% and HCS RR=88%)<br>Nqual=60 (HCS 30 +NSHD 30) | Reporting bias | Low | Univariate analysis explained the correlation between neighbourhood cohesion and MWB, however, for multivariate analysis only the association between the SD of neighbourhood coehesion and MWB was assessed. | **MMAT 11/13** | QUAL 4/4 | QUANT 3/4 | MIXED 4/5 | |

| Paper | Type | Population and Response Rate (RR) | Bias | Risk | Limitation | QA | Selection | Comparability | Outcome | Exclude |
|---|---|---|---|---|---|---|---|---|---|---|
| *Fisher, K. and F. Li (2004)* | *RCT* | *N=582*<br>*RR not reported* | *Selection bias*<br>*Attrition bias*<br>*Measurement bias*<br>*Reporting bias* | *High* | *The actual intervention did not involve the entire community;*<br>*No report for the initial RR, and 24% (138/582) loss to follow up with no information on which group they belong to;*<br>*The results were measured by a mean slop, no statistical power on explaining association;*<br>*The recruiting process explained really confusing.* | ***CASP 3/11*** | | | | |
| *Fox et al. (2007)* | *Mixed Methods-*<br>*Explanatory Design*<br>*Focus group* | *N=176, initial RR=86.3%*<br>*(64/79 controls and 112/125 intervention)*<br>*(40/79 controls and 92/125 interventions at completion)*<br>*N=24 interviewees* | *Selection bias*<br>*Attrition bias*<br>*Measurement bias*<br>*Reporting bias* | *High* | *NO control groups analysis, no personal demographic characters analysis, bivariate correlation only for the quantitative analysis.*<br>*High drop-out, and the drop-out were not analyzed.*<br>*Inconsistant measures of WB, no information on which WB measures was used.*<br>*The degree to which these positive outcomes translated into higher order aspects of wellbeing is difficult to conclude.* | ***MMAT 5/13*** | *QUAL 1/4* | *QUANT 1/4* | *MIXED 3/5* | |
| *Frazier, C., et al. (2005)* | *Cross-sectional* | *N=86*<br>*(RR=93.5% of participants; RR=29.2% of total recruited)* | *Selection bias*<br>*Attrition bias*<br>*Reporting bias* | *High* | *Very Low sample size which might not be representive, non randomized sampling.*<br>*Lack of sample-specific reliability due to inadvertent loss of the raw data. RR of the toal recruited was low.*<br>*Insignificant results. No significant association been fund.* | ***NOS 2/10*** | *1* | *0* | *1* | X |
| *Gabriel, Z. and A. Bowling (2004)* | *Qualitative study* | *N=80 Interviewed sample (RR=75.5%)*<br>*P=999 Survey population (RR=77%)* | *Selection bias*<br>*Attrition bias* | *Moderate* | *Purposive interview selected 40 men and 40 women from the original population of 999 surveyed older people. No information on how the interviewed sample were picked and which QoL group they belonged to.*<br>*75.5% (80/106) responded for the interview, with no information on the refused.* | ***CASP 6/10*** | | | | |
| *Gale, C. R., et al. (2011)* | *Cross-sectional*<br>*(HCS Cohort)* | *N=1157*<br>*(RR=82% on MWB questions)* | *Reporting bias* | *Moderate* | *Only the association between the SD of neighbourhood coehesion and MWB was assessed.* | ***NOS 7/10*** | *4* | *2* | *1* | |
| *Gautam, R., et al. (2007).* | *Cross-sectional* | *N=489*<br>*(RR=34.8%)* | *Selection bias*<br>*Attrition bias* | *High* | *The study sample was derived from a survey which aimed to examine the relationship between older adults and their married son, which might not be representive.*<br>*High refused to participate.* | ***NOS 4/10*** | *1* | *2* | *1* | |
| *Golden, J., et al. (2009)* | *Cross-sectional* | *N=1334*<br>*(RR not reported)* | *Attrition bias*<br>*Reporting bias* | *High* | *No response rate for the participants*<br>*Only odd ratio as result. Very weak power on reporting association between determinants and MWB.* | ***NOS 3/10*** | *1* | *1* | *1* | |
| *Gouveia, É. R. Q., et al. (2017)* | *Cross-sectional* | *N=802*<br>*(RR not reported)* | *Selection bias*<br>*Attrition bias* | *Moderate* | *The participants were volunteers recruited from social centres and sport clubs and etc;*<br>*No response rate for the participants, which may have bias because respondents are probably healthier and more physically active/fitted than non-respondents;* | ***NOS 5/10*** | *2* | *2* | *1* | |
| *Gow, A. J., et al. (2007)* | *Cohort Study* | *N=488*<br>*(RR=87.5%)* | *Attrition bias*<br>*Reporting bias* | *Moderate* | *The respondent at age 79 were only 0.63% (550/87498) of the original population, high rate of lost to follow up.*<br>*The results in the paper were not consistant on the numbers (in text and in table)*<br>*The response rate again not consistant on the number.* | ***NOS 5/9*** | *2* | *2* | *1* | |
| *Greenfield, E. A. and N. F. Marks (2004)* | *Cross-sectional* | *N=373*<br>*(RR=60.8%)* | *Measurement bias* | *Moderate* | *Formal volunteering only (36% of the participants).* | ***NOS 6/10*** | *3* | *2* | *1* | |
| *Heo, J., et al. (2015)* | *Cross-sectional* | *N=5203*<br>*(RR not reported)* | *Attrition bias*<br>*Reporting bias* | *Moderate* | *No response rate for the participants*<br>*Bivariate correlation only for the quantitative analysis, no other covariates were considered into analysis.* | ***NOS 5/10*** | *3* | *1* | *1* | |
| *Huxhold, O., et al. (2013)* | *Longitudinal* | *N=667*<br>*(RR=32.8% of the baseline sample size)* | *Attrition bias* | *Low* | *As indicated by the author, follow-up participants were on average younger, healthier (physically and mentally), and better educated than were those in the baseline sample.* | ***NOS 7/9*** | *4* | *2* | *1* | |
| *Jang, Y., et al. (2006)* | *Cross-sectional* | *N=255*<br>*(RR=60.1%)* | *Selection bias*<br>*Attrition bias* | *High* | *The sample were selected from one county in Florida, which might not applied in other places in the US.*<br>*No report on the participants who refused.* | ***NOS 4/10*** | *1* | *2* | *1* | |
| *Ju, Y. J., et al. (2016)* | *Longitudinal* | *N=3274*<br>*(baseline sample size, RR not reported)* | *Attrition bias*<br>*Measurement bias*<br>*Reporting bias* | *High* | *No RR, no information on the missing and loss to follow-up.*<br>*Single-item scale rating from 0-100 on overall QoL.*<br>*Longitudinal dataset but analysis performed as cross-sectional dataset with only baseline variables analysed. Longitudinal regression method used might not appropriate. Results did not make sence.* | ***NOS 4/9*** | *1* | *2* | *1* | |
| *Kadowaki, L., et al. (2015)* | *Cross-sectional* | *N=3244*<br>*(RR=19.8%)* | *Selection bias*<br>*Attrition bias* | *Moderate* | *This study restricted to older adults who had received home care services and/or identified that they had unmet professional home care needs 19.8% (3244/16369) of the total participants aged 65=+. The effects of the determinants may vary if consider total population. Indeed, the one received home care or have needs unmet might have greater posibility of more chronic conditions, and higher level of functional impairment.* | ***NOS 5/10*** | *2* | *2* | *1* | |
| *Kahana, E., et al. (2013)* | *Longitudinal* | *N=585*<br>*(RR=58.5%)* | *Selection bias*<br>*Attrition bias* | *Moderate* | *Include only "sufficiently healthy" participants*<br>*Missing data and loss to follow-up reported by the author as "the respondents who died or dropped out by Wave 5 were significantly older, more functionally impaired and less likely to volunteer (p < .05) at Wave 1."* | ***NOS 6/9*** | *3* | *2* | *1* | |
| *Kirchmann, H., et al. (2013)* | *Cross-sectional* | *N=81*<br>*(RR=33.2%)* | *Selection bias*<br>*Attrition bias* | *Moderate* | *The participants were patients of a general practitioner in Germany, which did not represent the entire population. The participants might share demographic characters in common. The participants were also within a Low age range (69-73).*<br>*RR=33.2% (87/244), high attrition bias on the refuse to participant.* | ***NOS 5/10*** | *1* | *2* | *2* | |
| *Kobayashi, E., et al. (2015)* | *Longitudinal* | *N=4917 observations*<br>*RR from 54%-74% for each waves* | *Attrition bias*<br>*Reporting bias* | *Low* | *9.2% of the participants have missing variables.*<br>*No clear reason/measure explained the cohorts different. Only separate cohort analysis were performed.* | ***NOS 7/9*** | *4* | *2* | *1* | |
| *Lee, Y.-J. and W.-L. Hung (2011)* | *Cross-sectional* | *N=352*<br>*(RR=88%)* | *Selection bias*<br>*Reporting bias* | *High* | *Only active participants were recruited, which might not represent the population.*<br>*Results did not make sense.* | ***NOS 4/10*** | *2* | *1* | *1* | X |
| *Levin, J. S., et al. (1996)* | *Longitudinal* | *N=111*<br>*(RR=29.6%)* | *Attrition bias*<br>*Reporting bias* | *Low* | *RR=29.6% at follow up, 53% (199/375) died.*<br>*Only cross-sectional results were supported.* | ***NOS 7/9*** | *4* | *2* | *1* | |

| Paper | Type | Population and Response Rate (RR) | Bias | Risk | Limitation | QA | Selection | Comparability | Outcome | Exclude |
|---|---|---|---|---|---|---|---|---|---|---|
| *Li, S., et al. (2012)* | *Cross-sectional* | *N=2342<br>(RR=98.9%, 0.8% of the total population in Xicheng district)* | *Selection bias<br>Attrition bias<br>Measurement bias* | *Moderate* | *Participants were only from one distrct in Beijing, which might not be representive.<br>Exclusion of 100 respondents that current are employed, which may lead to bias in results.<br>Some variables were not validated measures.* | ***NOS 6/10*** | *2* | *2* | *2* | |
| *Lim, H. J., et al. (2017)* | *Longitudinal* | *N=1954<br>(RR=55.6% of baseline)* | *Attrition bias<br>Measurement bias<br>Reporting bias* | *High* | *No information on the missing variables.<br>LS measure only focus on particular area that linked with current study.<br>Only odd ratio as result. Very weak power on reporting association between determinants and MWB.* | ***NOS 3/9*** | *2* | *0* | *1* | |
| *López García, E., et al. (2005)* | *Cross-sectional* | *N=3600<br>(RR=63.9%)* | *Measurement bias* | *Moderate* | *Whether married status belongs to social-demographic or social network still need to be consider. No social network varibles indicated other than family member.* | ***NOS 6/10*** | *3* | *2* | *1* | |
| *Lowis, M. J., et al. (2011)* | *Cross-sectional* | *N=121<br>(RR=74.5%)* | *Selection bias<br>Measurement bias* | *High* | *Low group of participants, no idea the geographical covers for these participants.<br>Retirment stress measure need to be adjusted: The elements that comprised the retirement stress subscale required participants to assess (retrospectively) how much they missed each of the following when they retired: social, income, activity, and making a meaningful contribution to life.* | ***NOS 3/10*** | *1* | *1* | *1* | |
| *Margelisch, K., et al. (2017)* | *Longitudinal* | *N=252<br>(RR=67% of baseline)* | *Attrition bias<br>Measurement bias* | *Moderate* | *Drop out rate 33%, and the droppers showed higher values of hopelessness and lower values of psychological resilience.<br>The determinant, psychological resilience, is a concept of MWB, should be highly correlated to MWB.* | ***NOS 5/9*** | *2* | *2* | *1* | |
| *Markides, K. S. and D. J. Lee (1990)* | *Longitudinal* | *N=254<br>(RR=50% of baseline)* | *Attrition bias* | *Moderate* | *50% dropped out were older, less likely to be married, more likely to be Anglos than Mexican Americans, had poorer functional health, lower self-ratings of health, lower activity scores, and lower life satisfaction scores.* | ***NOS 5/9*** | *3* | *1* | *1* | |
| *McAuley, E., et al. (2000)* | *RCT* | *N=174<br>(Missing data on dependent variables RR=87%, and independent varibles RR=)* | *Selection bias<br>Attrition bias* | *High* | *Predominantly female (male 49; female 125). No control group.<br>Missing data on dependent variables and independent varibles, log-likelihood of the data is calculated providing reliable standard errors for the missing data case.* | ***CASP 4/11*** | | | | |
| *Merz, E.-M. and N. S. Consedine (2009)* | *Cross-sectional* | *N=1118<br>(RR not reported)* | *Selection bias<br>Attrition bias* | *Moderate* | *Ethinicity groups were: US-born African Americans, US-born European Americans, immigrants from the English-speaking Caribbean (almost exclusively from Jamaica, Trinidad and Tobago, and Barbados), and immigrant Eastern Europeans, predominantly from Russia, the Ukraine, and Poland, which may not represnt the population ethnicity.<br>RR not reported* | ***NOS 5/10*** | *1* | *2* | *2* | |
| *Merz, E.-M. and O. Huxhold (2010)* | *Cross-sectional* | *N=1146<br>(RR not reported)* | *Attrition bias<br>Reporting bias* | *Moderate* | *RR not reported<br>Only variance ratios were performed as results.* | ***NOS 5/10*** | *3* | *1* | *1* | |
| *Momtaz, Y. A., et al. (2010)* | *Cross-sectional* | *N=1367 (RR=81.3%)* | *Attrition bias* | *Moderate* | *No information on the missing variables.* | ***NOS 7/10*** | *3* | *2* | *2* | |
| *Momtaz, Y. A., et al. (2016)* | *Cross-sectional* | *N=2202<br>(RR=87.6%)* | *Attrition bias<br>Reporting bias* | *Moderate* | *No information on the missing variables.<br>Only odd ratio as result. Very weak power on reporting association between determinants and MWB.* | ***NOS 5/10*** | *3* | *1* | *1* | |
| *Ng, S. T., et al. (2017)* | *Cross-sectional* | *N=6530<br>(RR not reported)* | *Attrition bias<br>Measurement bias<br>Reporting bias* | *Moderate* | *RR not reported<br>Single question of LS might have measurement bias.<br>No reported reference group, results unclear.* | ***NOS 6/10*** | *3* | *2* | *1* | |
| *Ní Mhaoláin, A. M., et al. (2012)* | *Cross-sectional* | *N=466 (RR=34.5%)* | *Attrition bias* | *Moderate* | *RR at low level* | ***NOS 5/10*** | *1* | *2* | *2* | |
| *Okabayashi, H., et al. (2004)* | *Cross-sectional* | *N=1299 for those with spouse and children (RR=96.3%)<br>N=677 for those with children only (RR=91.2%)* | *Selection bias<br>Attrition bias* | *Moderate* | *The exlusion of those with spouse (N=51) only and those without spouse and children (N=58) might lead to bias in results.<br>No information on the missing variables.* | ***NOS 5/10*** | *2* | *2* | *1* | |
| *Olsson, L. A., et al. (2014)* | *Cross-sectional* | *N=389<br>(RR not reported)* | *Selection bias<br>Attrition bias* | *Moderate* | *No recruiting information, no RR. Participants assumed to be more healthy and active then the average population.* | ***NOS 5/10*** | *2* | *2* | *1* | |
| *Park, J., et al. (2012)* | *Cross-sectional* | *N=200 (RR=96.6%)* | *Selection bias* | *Moderate* | *Participants were not random selected. Population were very specified to elder Korean immigrants in New York city.* | ***NOS 5/10*** | *2* | *2* | *1* | |
| *Park, M., et al. (2014)* | *Cross-sectional* | *N=2356<br>(RR not reported)* | *Selection bias<br>Attrition bias<br>Measurement bias* | *Moderate* | *Include women participants only<br>RR not reported<br>Single question of LS might have measurement bias.* | ***NOS 6/10*** | *3* | *2* | *1* | |
| *Shin, S. H. and S. R. Sok (2012)* | *Cross-sectional* | *N=300<br>(RR=88.2%)* | *Selection bias<br>Attrition bias<br>Reporting bias* | *High* | *Random sampling, however, the sample size is very Low. Half living with family and half livinf alone might not be the actrual distribution.<br>Missing data might lead to bias.<br>Results were inconsistant, wrong results* | ***NOS 4/10*** | *2* | *1* | *1* | X |
| *Silverstein, M., et al. (2006)* | *Cross-sectional* | *N=1561 (RR=86.7%)* | *Selection bias* | *Moderate* | *Rural chinese population from one town only.* | ***NOS 5/10*** | *2* | *2* | *1* | |
| *Stathi, A., et al. (2002)* | *Qualitative study* | *N=28<br>(RR not reported)* | *Selection bias<br>Attrition* | *Moderate* | *Including only active participants in this study might lead to bias in result.<br>RR not reported* | ***CASP 6/10*** | | | | |
| *Sun, W., et al. (2015)* | *Cross-sectional* | *N=3714<br>(RR=78.5%)* | *Measurement bias* | *Moderate* | *Measurements of some assessed factors, such as smoking and alcohol consumption, were simplistic and broad, which might weaken the assessments of their effects.* | ***NOS 6/10*** | *3* | *2* | *1* | |
| *Sun, X., et al. (2017)* | *Cross-sectional* | *N=975<br>(RR=0.05% of the population)* | *Selection bias<br>Attrition bias* | *Moderate* | *Rural chinese population only. Non-strict randomisation design.<br>The RR was very low compare to the population* | ***NOS 5/10*** | *1* | *2* | *2* | |

| Paper | Type | Population and Response Rate (RR) | Bias | Risk | Limitation | QA | Selection | Comparability | Outcome | Exclude |
|---|---|---|---|---|---|---|---|---|---|---|
| *Tajvar, M., et al. (2008)* | *Cross-sectional* | *N=400*<br>*(RR not reported)* | *Attrition bias*<br>*Reporting bias* | *Moderate* | *RR not reported*<br>*Only odd ratio as result. Very weak power on reporting association between determinants and MWB.* | ***NOS 5/10*** | *3* | *1* | *1* | |
| *Thanakwang, K., et al. (2012)* | *Cross-sectional* | *N=469*<br>*(RR not reported)* | *Selection bias*<br>*Attrition bias*<br>*Reporting bias* | *High* | *Participants were from one provience in Thailand, which might not be represetive to the entire Thai population.*<br>*RR not reported*<br>*The impact of ADL functioning was not explained.* | ***NOS 4/10*** | *1* | *1* | *2* | |
| *Vagetti, G. C., et al. (2015)* | *Cross-sectional* | *N=1806*<br>*(RR=95.3%)* | *Selection bias*<br>*Reporting bias* | *Moderate* | *Only female participants. The program recruited more women (N=4346) than men (N=110).*<br>*Only odd ratio as result. Very weak power on reporting association between determinants and MWB.* | ***NOS 5/10*** | *3* | *1* | *1* | |
| *Van Hoecke, A. S., et al. (2014)* | *RCT* | *N=422 at 10-week follow-up (RR=95.5% of baseline)*<br>*N=348 at 1-year follow-up (RR=78.7% of baseline)*<br>*N=344 at 2-year follow-up (RR=77.8% of baseline)* | *Selection bias*<br>*Attrition bias* | *Moderate* | *Healthy and active participants, and lack of a strict control condition.*<br>*Drop-outs due to health, family-related, lack of motivation, unable to contact, lack of time and unknown reasons, and they were significantly different from nondrop-outs.* | ***CASP 6/11*** | | | | |
| *Waddell, E. L. and J. M. Jacobs-Lawson (2010)* | *Cross-sectional* | *N=800*<br>*(RR not reported)* | *Attrition bias*<br>*Reporting bias* | *High* | *RR not reported*<br>*Some variables were reverse-coded as linked to worse positive mental well-being, which might not be significant when suggesting the positive association with positive well-being.* | ***NOS 3/10*** | *1* | *1* | *1* | |
| *Windle, G. and R. T. Woods (2004)* | *Cross-sectional* | *N=423*<br>*(RR=54%)* | *Attrition bias*<br>*Measurement bias*<br>*Reporting bias* | *Moderate* | *RR=54% might indicate bias on sample population*<br>*Scoring syetem for independent variables did not explain the result findings*<br>*The direct /indirect effect did not explained well. The analysis assummed that there was a mediator, which might not be true.* | ***NOS 5/10*** | *2* | *2* | *1* | |
| *Ye, M. and Y. Chen (2014)* | *Cross-sectional* | *N=939*<br>*(RR not reported)* | *Selection bias*<br>*Attrition bias* | *Moderate* | *Participants were from one Shanghai central district, the Low sample size might not be representive.*<br>*RR not reported* | ***NOS 5/10*** | *2* | *2* | *1* | |
| *Yoon, D. P. and E.-K. O. Lee (2007)* | *Cross-sectional* | *N=215*<br>*(RR not reported)* | *Selection bias*<br>*Attrition bias* | *High* | *Non-random and Low-size sample, which might not be representive.*<br>*RR not reported* | ***NOS 4/10*** | *1* | *2* | *1* | |
| *Zimmer, Z. and H.-S. Lin (1996)* | *Cross-sectional* | *N=4049 (RR=92%)* | *Attrition bias* | *Moderate* | *Missing variables were not analysed* | ***NOS 6/10*** | *3* | *2* | *1* | |

# 2. Consequences of MWB

## 2.1 The summarised findings from reviewed papers

| Author | Method | Sample size (response rate) | Outcome variables | Mortality rate | MWB Measurement | Covariates | Adjustments | Comparison | Results |
|---|---|---|---|---|---|---|---|---|---|
| Andrew (2012) | Logistic regression | N=5703 (baseline RR=63.3%, no RR at follow-up) | **Mortality** (upto 5 years) | not mentioned | **Psychological well-being** (Ryff scale 18-108 worse PWB) | Age, sex, education, frailty, mental health (MHI-5), and cognition (3MS score) | n/a | N/A (not mentioned) | For each additional point **worsening in psychological wellbeing**, **the odds of 5-year mortality increased by 1% (OR 1.01, 95% CI: 1.00–1.03, p=0.02)**. No longer statistically significant once baseline 3MS score was taken into account. |
| Blazer & Hybels (2004) | Cox proportional hazards model | N=3673 (88.25%) | **Mortality (upto 10 years)** | 51% | **Positive affect (Positive-4 of CES-D 0-12 higher WB)** | Age, sex, ethnicity, married status, education, income, cognitive impairment, functional impairment | fully adjusted | N/A (not mentioned) | **Low positive affect (HR 1.12, 95%CI 1.05–1.18, P=0.000) remains a significant predictor of mortality** when potential confounders are controlled. |
| Bowling & Grundy (2009) | Cox proportional hazards model | N=1,384, (RR=70%, 67% and 82%, for the combined sample) | **Mortality** (upto 20 years) | 1121 (87.5%) | **Life Satisfaction Scale** (Neugarten's LS scale 0-20 higher well-being) | Year of birth, sex, housing tenure , ADL, social factors, area of residence, reported loneliness, and year of baseline interview | fully adjusted | All included | The hazard ratio was significantly decreased for **each unit increase in life satisfaction (HR 0.985, 95%CI 0.970–0.999, P=0.040)** |
| | | | | | | | | Men vs. Women | **The hazards for females, but not males**, were significantly reduced with **each unit increase in life satisfaction (HR 0.979, 95%CI 0.062–0.996, P=0.015)** |
| | | | | | | | | 65~85 vs. 85+ | **In the 85+ sample only**, the hazards rate was significant and was reduced with **each unit increase in life satisfaction (HR 0.980, 95% CI 0.961–1.000, P=0.045)** |
| Hirosaki (2013) | Multiple logistic regression | N=505 (initial RR=62.2%, RR=46.5% at follow-up) | **Functional decline** (BADL upto 2 years) | n/a | **Positive affect** (Positive-5 of GDS-15) | Age, sex, marital status, living conditions, smoking, drinking, higher-level functional capacity and medical conditions | fully adjusted | N/A (not mentioned) | **Positive-5 (OR 0.78, 95% CI 0.64–0.97, p=0.023) significantly predicted a lower risk of functional decline** when adjusting for potential confounding factors at 2-years follow-up. After adding negative affect as confounders, **Positive-5 (OR 0.66, 95% CI 0.50–0.89, p=0.005)** was still significantly associated with lower risk of functional decline. |
| Kimm (2012) | Cox proportional hazards model | N=1939 (RR=53.9%) | **Mortality** (up to 11.8 years) | 1318 (68.0%) | **Life satisfaction** (Neugarten's LSI-A index 0-40 satisfied) | Age, sex, education, chronic disease conditions, health behaviours (smoking and drinking), MMSE, ADL, IADL | adjusted for age only | Satisfied vs. unsatisfied | The **unsatisfied group's HR of all-cause mortality**, compared to the satisfied group, was **1.61 (95% CI, 1.26-2.04) for men; and 1.61 (95% CI, 1.27-2.03) for women**. |
| | | | | | | | fully adjusted | Satisfied vs. unsatisfied | The **unsatisfied group's HR of all-cause mortality**, compared to the satisfied group, was **1.42 (95% CI, 1.11-1.83) for men; and 1.51 (95% CI, 1.18-1.92) for women**. |
| Koopmans (2010) | Cox proportional hazards model | N=861 (baseline RR=56.4%, final included RR=48.0%) | **Mortality** (up to 15 years) | 580 (67.4%) | **Happiness** (subjective happiness 0-4 happy) | Age, sex, marital status, educational history, social economic status, chronic disease, smoking and physical activity | unadjusted | Happy vs. unhappy | **Hazard ratio of 0.72 (95% CI 0.59–0.88, P = 0.002)** for happy subjects versus unhappy subjects |
| | | | | | | | adjusted for age and sex | Happy vs. unhappy | **Hazard ratio of 0.78 (95% CI 0.64–0.95, P = 0.01)** for happy subjects versus unhappy subjects |
| | | | | | | | adjusted for sex, age, marital status, educational history and social economic status | Happy vs. unhappy | **Hazard ratio of 0.77 (95% CI 0.63–0.95, P = 0.01)** for happy subjects versus unhappy subjects |
| | | | | | | | fully adjusted with PA | Happy vs. unhappy | not significant |
| Li (2013) | Cox proportional hazards model | **NLSAA** N=690 (baseline RR=80.2%, RR=53.1% for study) | **Mortality** (upto 14 years) | 418 (60.6%) | **Life satisfaction** (LSI-Z scale 0-100 satisfied) | Age, sex, marital status, social economic status, self-rated health, smoking, diseases, loneliness, depression, and social activity (i.e., attending religious group, having friend etc.) | unadjusted | N/A (not mentioned) | Each **increase in the standardized LSI score, risk of mortality decreased by 0.01 (hazard ratio 0.990, 95%CI 0.986-0.995, p<0.001)** |
| | | | | | | | adjusted for age, sex, marital status, social economic status | | Each **increase in the standardized LSI score, risk of mortality decreased by 0.01 (hazard ratio 0.990, 95%CI 0.985-0.995, p<0.001)** |
| | | | | | | | fully adjusted included mental health | | Each **increase in the standardized LSI score, risk of mortality decreased by 0.007 (hazard ratio 0.993, 95%CI 0.987-0.999, p=0.028)** |
| | | **SHLSET** N=1438 (baseline RR=91.8%, RR=32.6% for study) | | 601 (41.8%) | **Life satisfaction** (LSI scale 0-100 satisfied) | | unadjusted | N/A (not mentioned) | Each **increase in the standardized LSI score, risk of mortality decreased by 0.006 (hazard ratio 0.994, 95%CI 0.990-0.997, p<0.001)** |
| | | | | | | | adjusted for age, sex, marital status, social economic status | | Each **increase in the standardized LSI score, risk of mortality decreased by 0.004 (hazard ratio 0.994, 95%CI 0.992-0.999, p=0.022)** |
| | | | | | | | fully adjusted included mental health | | not significant |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mete, C. (2005) | Probit model | N=3611 (baseline 91.8%, follow-up 89.2%) | **Mortality (upto 7 years)** | 849 (23.5%)) | **Life satisfaction (LSI modified 0-1 satisfied)** | Age, sex, ethnicity, marital status, education, social economic status, self-rated health, ADL, CD | fully adjusted included physical health | N/A (not mentioned) | An individual **at the 75th percentile of the LSI distribution** (with an index value of 0.8) is **3.5% more likely to be alive** in 1996 compared to an individual at the 25th percentile of the LSI distribution (with an index value of 0.4). |
| Ostir (2000) | Logistic regression | N=2282 (baseline RR=74.8%, RR=60.9% for follow-up) | **Functional decline** (Katz Index of ADL, 0-7 more ADL problems upto 2 years) | 108 (4.7%) | **Positive affect** (Positive-4 of CES-D 0-12 higher WB) | Age, sex, marital status, education, language of interview, BMI, smoking status, alcohol use, negative affect, and chronic conditions | adjusted for age, sex, marital status, education, language of interview, BMI, smoking, alcohol use, negative affect | N/A (not mentioned) | For each point increase in positive affect score at baseline was associated with **decreasing risk of ADL limitation at follow-up (OR 0.91; 95%CI 0.85-0.98)** |
| | | | | | | | fully adjusted with CD | | For each point increase in positive affect score at baseline was associated with **decreasing risk of ADL limitation at follow-up (OR 0.94; 95%CI 0.89-0.99)** |
| | | | **Mortality** (upto 2 years) | | | | Adjusted for age, sex, marital status, education, language of interview, BMI, smoking, alcohol use, negative affect | High positive affect vs. Low positive affect | Individuals who reported a positive affect score of 12 at baseline significantly reduced risk for mortality compared to those with a positive affect score of 0 to 11 **(OR 0.47; 95% CI 0.24-0.93)** |
| | | | | | | | fully adjusted with CD | | Individuals who reported a positive affect score of 12 at baseline significantly reduced risk for mortality compared to those with a positive affect score of 0 to 11 **(OR 0.53; 95% CI 0.30-0.93)** |
| Ostir (2001) | Cox proportional hazards model | N=2478 (RR=65.4%) | **Risk of Stroke** (summing the number of physician-diagnosed strokes and the number of deaths that stroke was listed as the cause of death during 6 years) | N/A | **Positive affect** (Positive-4 of CES-D 0-12 higher positive affect ) | Age, sex, marital status, education, household income, BMI, smoking status, negative affect, and chronic conditions | fully adjusted | All included | **Positive affect** score demonstrated a strong **inverse association with stroke incidence (RR=0.74, 95%CI 0.62–0.88, p=0.0006)**. |
| | | | | | | | | Men vs. Women | **Positive affect** score demonstrated a strong **inverse association with stroke incidence** for both men and women. Results were **stronger for men**, in whom each unit increase in positive affect was associated with a **41% (RR=0.59, 95%CI 0.45–0.78, p=0.0002)** decrease in the incidence of stroke, than for **women (RR=0.82, 95%CI 0.66–1, p=0.05)**. |
| | | | | | | | | Whites vs. Blacks | **Positive affect** score demonstrated a strong **inverse association with stroke incidence** for both **Whites (RR=0.78, 95%CI 0.62–0.98, p=0.04)** and **Blacks (RR=0.73, 95%CI 0.56–0.95, p=0.02)**. |
| Otero-Rodríguez (2010) | Cox proportional hazards model | N=2373 (baseline RR=99.7%, RR=59.2% for study) | **Mortality** (upto 4 years) | 212 (8.9%) | **HRQoL** (baseline MCS) | Age, sex, baseline HRQoL, educational, marital status, tobacco use, alcohol consumption, leisure-time physical activity, BMI, baseline chronic diseases and change in PCS | In all model | N/A (not mentioned) | Baseline MCS showed no significance association with mortality |
| | | | | | **Changes in MCS in 2 years before study** (Spanish version SF-36 0-100 better HRQoL) | | adjusted for age, sex, marital status, social economic status | Decrease of >10 points in the MCS vs. Changes of -5~5 points in the MCS | **82% increase in mortality (HR 1.82; 95% CI 1.29-2.57, p<0.001)** |
| | | | | | | | adjusted for age, sex, baseline HRQoL, educational, marital status, smoking, drinking, leisure-time physical activity, BMI and baseline CD | | **63% increase in mortality (HR 1.63; 95% CI 1.14-2.32, p<0.01)** |
| | | | | | | | fully adjusted included change in PCS | | **60% increase in mortality (HR 1.60; 95% CI 1.12-2.28, p<0.05)** |
| | | | | | | | adjusted for age, sex, marital status, social economic status | Continued good mental health (MCS >50 points) vs. Recovering health (MCS from <=50 to >50) vs. Declining health (MCS from >50 to <=50) vs. Continued poor health (MCS from <=50 to <=50) | **Recovering health (HR 1.70; 95% CI 1.02-2.84, p<0.05), Declining health (HR 1.86; 95% CI 1.29-2.69, p<0.01), Continued poor health (HR 2.05; 95% CI 1.23-3.43, p<0.01)** |
| | | | | | | | adjusted for age, sex, baseline HRQoL, educational, marital status, smoking, drinking, leisure-time physical activity, BMI and baseline CD | | only significant for **Declining health (HR 1.65; 95% CI 1.14-2.40, p<0.01)** |
| | | | | | | | fully adjusted included change in PCS | | not significant |
| Sadler (2011) | Cox proportional | | **Mortality** (upto 9 years) | 2439 (61.5%) | | Age, sex, number of medications, number | adjusted for age and sex | N/A | **Life satisfaction (HR 0.80, 95%CI 0.77 – 0.83, p=0.000) was associated with a reduction in mortality risk** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *hazards models* | *N=3,966 twins (RR=83.8% for study)* | | | ***Life satisfaction*** *(single subjective question 1-5 low LS)* | *of illnesses and cognitive composite* | *fully adjusted* | | ***Life satisfaction (HR 0.87, 95%CI 0.83 – 0.91, p=0.000) was associated with a reduction in mortality risk*** |
| *Tsai (2007)* | *Logistic regression* | *N=4424 (baseline RR=73%, RR=45.7% for follow-up)* | ***Mortality*** *(upto 3 years)* | *221 (5.0%)* | ***HRQoL*** *(MCS in Chinese version SF-36 0-100 better HRQoL)* | *Age, sex, feeling dizzy, feeling tired, asthmatic symptoms, chest pain, smoking, fall, stroke, and utilization of inpatient and emergency services in last 3 months* | *fully adjusted* | *N/A (not mentioned)* | ***A 10-point decrease from baseline MCS score (RR: 1.16; 95% CI: 1.01–1.34; p = 0.036) was a significant predictor of mortality*** |

## 2.2 Quality assessments results

| Paper | Selection (Max 4) | | | | Comparability (Max 2) | Outcome (Max 3) | | | QA Score | Quality | Risk of Bias |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Representativeness of the exposed cohort | Selection of the non-exposed cohort | Ascertainment of exposure to implants | Demonstration that no history of disease at start of study | Comparability of cohorts on the basis of the design or analysis | Assessment of outcome | Was follow up long enough for outcomes to occur | Adequacy of follow up of cohorts | | | |
| Andrew (2012) | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | **4** | **Low** | *Selection bias: no data available at follow-up*<br>*Attrition bias: no RR at follow-up*<br>*Reporting bias: no mortality rate at follow-up* |
| Blazer & Hybels (2004) | 0 | 0.5 | 0 | 0.5 | 2 | 1 | 1 | 0 | **5** | **Moderate** | *Selection bias: 55% African Americans, biracial sample only*<br>*Attrition bias: no RR at baseline* |
| Bowling & Grundy (2009) | 0 | 0.5 | 1 | 0.5 | 2 | 1 | 1 | 1 | **7** | **Moderate** | *Selection bias: from East London and Esses only* |
| Hirosaki (2013) | 0.5 | 1 | 0 | 0.5 | 2 | 0.5 | 0.5 | 0 | **5** | **Moderate** | *Selection bias: from only one town*<br>*Attrition bias: initial RR=62.2%, RR=46.5% at 2 years follow-up, no data about those lost*<br>*Reporting bias: all self-reported* |
| Kimm (2012) | 0 | 0.5 | 1 | 0 | 2 | 1 | 1 | 0.5 | **5** | **Moderate** | *Selection bias: from one rural island in South Korea*<br>*Attrition bias: initial RR=67.9%, RR=53.9% at follow-up*<br>*Reporting bias: all self-reported* |
| Koopmans (2010) | 1 | 1 | 1 | 0.5 | 2 | 0 | 1 | 0.5 | **7** | **Moderate** | *Attrition bias: initial RR=58%, RR=85.1% at follow-up*<br>*Reporting bias: no mortality rate at follow-up (replied by the author only)* |
| Li (2013) | 0.5 | 0.5 | 0 | 0.5 | 2 | 1 | 1 | 0.5 | **6** | **Moderate** | *Attrition bias: initial RR=80.2%, RR=88.3% at follow-up (UK sample)*<br>*initial RR=91.8%, RR=35.5% at follow-up (Taiwan sample)*<br>*Reporting bias: secondary datasets analysis* |
| Mete (2005) | 1 | 1 | 0 | 0 | 0.5 | 0 | 1 | 0.5 | **4** | **Low** | *Measurement bias: LSI modified at a scale 0-1*<br>*Reporting bias: continuous mortality data not available, only probit model was used; secondary datasets analysis* |
| Ostir (2000) | 0.5 | 1 | 1 | 0.5 | 2 | 1 | 1 | 1 | **8** | **Moderate** | *Attrition bias: initial RR=74.8%, RR=60.9% at 2 years follow-up*<br>*Selection bias: 2-years follow-up period was very short* |
| Ostir (2001) | 0 | 0.5 | 1 | 1 | 2 | 1 | 1 | 0.5 | **7** | **Moderate** | *Selection bias: 55% African Americans, biracial sample only*<br>*Attrition bias: no RR at baseline, RR=65.4% at follow-up* |
| Otero-Rodríguez (2010) | 1 | 1 | 1 | 0.5 | 1 | 1 | 0.5 | 0.5 | **6.5** | **Moderate** | *Attrition bias: RR=59.2% for study*<br>*Measurement bias: Changes in SF-36 MCS only, hard to compare* |
| Sadler (2011) | 0.5 | 0.5 | 0 | 1 | 1 | 0 | 1 | 0.5 | **4.5** | **Moderate** | *Selection bias: only twins sample*<br>*Measurement bias: single subjective question on LS*<br>*Reporting bias: secondary datasets analysis* |
| Tsai (2007) | 0.5 | 1 | 0 | 0 | 1 | 0.5 | 0.5 | 1 | **4.5** | **Moderate** | *Selection bias: Mortality might caused by other disease, 2-years follow-up period was very short*<br>*Attrition bias: initial RR=73%, RR=74% at follow-up*<br>*Measurement bias: MWB was measured by changes in SF-36 MCS only, hard to compare* |

## 2.3 A summary of reviewed papers on MWB consequences on mortality

| Author | Measure of Well-being | How are comparators treated | How is the survival presented? | Years of Follow-up | Conclusion | Note |
|---|---|---|---|---|---|---|
| **Andrew 2012** | Ryff's PWB | OR presented by unit increase | Odds of mortality. Total number of deaths are not reported. | 10 | Can't get HR as OR from a 10-year period cannot be used to obtain a HR | |
| **Blazer 2004** | Positive affect | HR presented by unit increase | Unadjusted OR and adjusted cox model | 10 | Can't be used as presents results per unit increase | |
| **Bowling 2009** | Life Satisfaction Scale | HR presented by unit increase | Fitted adjusted cox models. Total deaths are presented. | 20 | Can't get unit or group specific OR but could get odds of event for whole population. | No evidence of suitability of Cox PH model provided |
| **Kimm 2012** | Life satisfaction index: LSI-A. | HR presented for unsatisfied group vs satisfied group | Fitted adjusted cox models. Results are presented by gender and by LSI group. Total deaths also presented. | 11.8 | Difficult to use as results are presented by gender. Could calculate OR from total number of deaths. | No evidence of suitability of Cox PH model provided |
| **Koopmans 2010** | Happiness | HR presented for unhappy group vs happy group | Fitted adjusted and unadjusted cox models. Total deaths are not presented | 14 | Data are not flexible. Only can use HR. | 74 cases were excluded on the basis of reverse causation.<br>PH assumption was tested. |
| **Li 2013** | LSI Z & LSI combine scale | HR presented for continuous increase | Fitted lots of adjusted cox models. Total deaths presented | 14 | Can't be used as unique scale. Total deaths are not provided by happiness group. | Unique scale makes use of HR difficult. |
| **Mete 2005** | LSI | Unit increase in LSI | Fits a probit model | 7 | Can't be used as results are per unit increase on probit scale | |
| **Ostir 2000** | Positive affect | OR presented for different categories | Adjusted OR presented for each category alongside number of deaths in each group. | 2 | Could potentially calculate crude HR, unclear whether confidence intervals could be meaningfully calculated | |
| **Otero Rodriguez 2010** | SF-36 MCS by change from baseline | HR presented for various change categories | Adjusted HR presented for various change categories, alongside number of deaths | 4-6 | Can't be used in MA, but useful for discussion. | |
| **Sadler 2011** | Life satisfaction by single question | HR presented but used standard deviations rather than unit increases | Adjusted HR, no deaths provided by group | 10-15 | Can't be used in as presents results used standard deviations | Twins study. Results are presented separately for DZ and MZ twins and excluded pairs of twins where neither had died. |
| **Tsai 2007** | SF-36 | Uses change from baseline | RR | 3 | | |

# APPENDIX C. SECONDARY ANALYSES

## 1. Data preparation-Chronic conditions

| | T1 | T2 | T3 | T1&T2 (remained) | T2&T3 (remained) | T1&T3 (remained) |
|---|---|---|---|---|---|---|
| no. of health conditions: 1 | 4,104 | 1,540 | 1,758 | 338 | 207 | 317 |
| no. of health conditions: 2 | 2,615 | 273 | 233 | 45 | 3 | 32 |
| no. of health conditions: 3 | 1,378 | 92 | 57 | 9 | - | 4 |
| no. of health conditions: 4 | 616 | 21 | 10 | - | - | - |
| no. of health conditions: 5 | 293 | 8 | 4 | 5 | - | - |
| no. of health conditions: 6 | 124 | 8 | - | - | - | - |
| no. of health conditions: 7 | 65 | 2 | - | - | - | - |
| no. of health conditions: 8 | 23 | - | - | - | - | - |
| no. of health conditions: 9 | 10 | - | - | - | - | - |
| no. of health conditions: 10 | 9 | 1 | - | - | - | - |
| N/A | 2,910 | 10,487 | 9,542 | 1,650 | 6,467 | 1,296 |
| **Total** | **12,147** | **12,432** | **11,604** | **2,044** | **6,677** | **1,649** |

Note: 1. N/A included: no diagnosed health conditions, missing, refusal, don't know, proxy and inapplicable. System missing were not included.

2. In UKHLS wave 1, diagnosed health conditions was only reported using variable _hcond, while in UKHLS wave 4 and wave 7, diagnosed health conditions were reported using variable _hcond and _hcondn. Both variables used same label and had same sample size. The final included variable from each waves were: wave1 a_hcond, wave4 d_hcondn and wave7 g_hcondn.

3. Health conditions included: Asthma, Arthritis, Congestive heart failure, Coronary heart disease, Angina, Heart attack or myocardial infarction, Stroke, Emphysema, Hyperthyroidism or an over-active thyroid, Hypothyroidism or an under-active thyroid, Chronic bronchitis, Any kind of liver condition, Cancer or malignancy, Diabetes, Epilepsy, High blood pressure and Clinical depression

## 2. Pairwise correlation at T1, T2 and T3

| | lnT1_SWEMWBS | T1_GH | T1_CD | T1_Age | T1_Sex | T1_FS | T1_MS | T1_ES | T1_Edu | T1_Reli | T1_SleepQual | T1_GHQ12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **lnT1_SWEMWBS** | - | | | | | | | | | | | |
| **T1_GH** | -0.3108* | - | | | | | | | | | | |
| **T1_CD** | -0.1789* | 0.4953* | - | | | | | | | | | |
| **T1_Age** | -0.0331* | 0.1521* | 0.1414* | - | | | | | | | | |
| **T1_Sex** | -0.0046 | -0.0059 | 0.0417* | 0.0391* | - | | | | | | | |
| **T1_FS** | -0.2131* | 0.2568* | 0.1504* | -0.0385* | 0.0070 | - | | | | | | |
| **T1_MS** | 0.0748* | -0.1058* | -0.1016* | -0.3503* | -0.2394* | -0.0687* | - | | | | | |
| **T1_ES** | 0.1025* | -0.2297* | -0.1616* | -0.2248* | -0.0900* | -0.1222* | 0.1260* | - | | | | |
| **T1_Educ** | 0.1257* | -0.2434* | -0.1197* | -0.2365* | -0.1214* | -0.1975* | 0.1544* | 0.1664* | - | | | |
| **T1_Religion** | 0.0245* | 0.0254* | 0.0434* | 0.1159* | 0.1306* | 0.0252* | -0.0348* | -0.0296* | -0.0379* | - | | |
| **T1_SleepQual** | -0.3454* | 0.3175* | 0.2157* | -0.0371* | 0.0983* | 0.1739* | -0.0528* | -0.0953* | -0.0828* | 0.0100 | - | |
| **T1_GHQ12** | -0.4260* | 0.3268* | 0.1773* | 0.0960* | 0.0171* | 0.2165* | -0.0660* | -0.1326* | -0.1613* | 0.0349* | 0.3902* | - |

Note: 1. GH (general health), CD (chronic disease), FS (financial situation), MS (marital status), ES (employment status), Edu (education), Reli (religion), SleepQual (sleep quality)
2. *indicated the pairwise correlation was significant at 95% confidence interval

| | lnT2_SWEMWBS | T2_GH | T2_CD | T2_Age | T2_Sex | T2_FS | T2_MS | T2_ES | T2_Edu | T2_Reli | T2_SleepQual | T2_GHQ12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **lnT2_SWEMWBS** | - | | | | | | | | | | | |
| **T2_GH** | -0.3495* | - | | | | | | | | | | |
| **T2_CD** | -0.1279* | 0.2126* | - | | | | | | | | | |
| **T2_Age** | -0.0215* | 0.1672* | 0.0394* | - | | | | | | | | |
| **T2_Sex** | -0.0331* | -0.0119 | 0.0062 | 0.0307* | - | | | | | | | |
| **T2_FS** | -0.2486* | 0.2586* | 0.0814* | -0.0841* | 0.0039 | - | | | | | | |
| **T2_MS** | 0.0638* | -0.1089* | -0.0375* | -0.3396* | -0.2278* | -0.0651* | - | | | | | |
| **T2_ES** | 0.1096* | -0.2363* | -0.0627* | -0.2419* | -0.0860* | -0.0947* | 0.1315* | - | | | | |
| **T2_Edu** | 0.1053* | -0.2404* | -0.0581* | -0.2272* | -0.1104* | -0.1827* | 0.1533* | 0.1669* | - | | | |
| **T2_Religion** | 0.0334* | 0.0213* | 0.0312* | 0.1261* | 0.1400* | 0.0102 | -0.0463* | -0.0586* | -0.0670* | - | | |
| **T2_SleepQual** | -0.3050* | 0.3357* | 0.1056* | -0.0387* | 0.1093* | 0.1892* | -0.0523* | -0.0812* | -0.1101* | -0.0022 | - | |
| **T2_GHQ12** | -0.4964* | 0.3488* | 0.1337* | 0.0926* | 0.0395* | 0.2066* | -0.0403* | -0.1242* | -0.1473* | 0.0390* | 0.2644* | - |

Note: 1. GH (general health), CD (chronic disease), FS (financial situation), MS (marital status), ES (employment status), Edu (education), Reli (religion), SleepQual (sleep quality)
2. *indicated the pairwise correlation was significant at 95% confidence interval

| | lnT3_SWEMWBS | T3_GH | T3_CD | T3_Age | T3_Sex | T3_FS | T3_MS | T3_ES | T3_Edu | T3_Reli | T3_SleepQual | T3_GHQ12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **lnT3_SWEMWBS** | - | | | | | | | | | | | |
| **T3_GH** | -0.3791* | - | | | | | | | | | | |
| **T3_CD** | -0.1187* | 0.2238* | - | | | | | | | | | |
| **T3_Age** | 0.0075 | 0.1057* | 0.0141 | - | | | | | | | | |
| **T3_Sex** | -0.0498* | 0.0191* | 0.0102 | 0.0218* | - | | | | | | | |
| **T3_FS** | -0.2570* | 0.2752* | 0.0696* | -0.0944* | 0.0219* | - | | | | | | |
| **T3_MS** | 0.0836* | -0.1035* | -0.0261* | -0.3240* | -0.2217* | -0.0990* | - | | | | | |
| **T3_ES** | 0.0849* | -0.1922* | -0.0551* | -0.2570* | -0.0940* | -0.0750* | 0.1184* | - | | | | |
| **T3_Edu** | 0.1032* | -0.2127* | -0.0306* | -0.2245* | -0.0971* | -0.1876* | 0.1567* | 0.1711* | - | | | |
| **T3_Religion** | 0.0117 | 0.0284* | -0.0030 | 0.1339* | 0.1307* | 0.0098 | -0.0560* | -0.0595* | -0.0686* | - | | |
| **T3_SleepQual** | -0.3010* | 0.3594* | 0.1057* | -0.0458* | 0.1159* | 0.1862* | -0.0561* | -0.0938* | -0.0834* | -0.0045 | - | |
| **T3_GHQ12** | -0.4700* | 0.3962* | 0.1638* | 0.0570* | 0.0380* | 0.2225* | -0.0481* | -0.1177* | -0.1219* | 0.0268* | 0.2911* | - |

Note: 1. GH (general health), CD (chronic disease), FS (financial situation), MS (marital status), ES (employment status), Edu (education), Reli (religion), SleepQual (sleep quality)

2. *indicated the pairwise correlation was significant at 95% confidence interval

# 3. Additional results tables

## 3.1 Cross-sectional analysis – multiple regression T1, T2 & T3

| | Multiple regression results-Cross-sectional correlations with SWEMWBS (p-value) 95%CI | | |
|---|---|---|---|
| **Determinants** | **T1 (PH only)** | **T1 (PH+DS)** | **T1 (PH+DS+PF)** |
| **R-squared (adjusted R-squared)** | **10.17% (10.09%)** | **13.14% (12.88%)** | **25.66% (25.40%)** |
| **General Health** | | | |
| Excellent (ref) | | | |
| Very good | **-0.0377 (0.000)** | **-0.0344 (0.000)** | **-0.0232 (0.000)** |
| Good | **-0.0757 (0.000)** | **-0.0663 (0.000)** | **-0.0418 (0.000)** |
| Fair | **-0.1302 (0.000)** | **-0.1105 (0.000)** | **-0.0653 (0.000)** |
| Poor | **-0.1998 (0.000)** | **-0.1680 (0.000)** | **-0.0767 (0.000)** |
| **Chronic Disease** | | | |
| No CD (ref) | | | |
| 1 | -0.0021 (0.678) | -0.0031 (0.538) | -0.0001 (0.976) |
| 2 | 0.0082 (0.165) | 0.0069 (0.239) | **0.0118 (0.031)** |
| 3-4 | -0.0105 (0.118) | -0.0110 (0.099) | 0.0024 (0.696) |
| 5 or more | **-0.0384 (0.000)** | **-0.0350 (0.001)** | -0.0147 (0.144) |
| **Age** | | | |
| 60-62 (ref) | | | |
| 63-65 | | 0.0076 (0.222) | 0.0046 (0.420) |
| 66-68 | | **0.0188 (0.005)** | 0.0083 (0.182) |
| 69-71 | | **0.0174 (0.015)** | 0.0080 (0.226) |
| 72-74 | | **0.0199 (0.009)** | 0.0070 (0.323) |
| 75-77 | | 0.0065 (0.439) | -0.0060 (0.438) |
| 78-80 | | 0.0147 (0.104) | -0.0001 (0.988) |
| 81-83 | | 0.0139 (0.177) | 0.0064 (0.502) |
| 84+ | | -0.0179 (0.078) | -0.0155 (0.101) |
| **Sex** | | | |
| Male (ref) | | | |
| Female | | -0.0002 (0.967) | **0.0122 (0.001)** |
| **Financial situation** | | | |
| Living comfortably (ref) | | | |
| Doing alright | | **-0.0282 (0.000)** | **-0.0216 (0.000)** |
| Just about getting by | | **-0.0459 (0.000)** | **-0.0284 (0.000)** |
| Finding it quite/very difficult | | **-0.1028 (0.000)** | **-0.0494 (0.000)** |
| **Marital Status** | | | |
| Widowed (ref) | | | |
| Single, Separated or Divorced | | 0.0029 (0.676) | -0.0016 (0.791) |
| Married, in a partnership or cohabit | | **0.0142 (0.010)** | 0.0075 (0.141) |
| **Employment Status** | | | |
| Inactive (including unemployed) (ref) | | | |
| Retired | | **0.0451 (0.000)** | **0.0340 (0.000)** |
| Employed | | **0.0432 (0.000)** | **0.0287 (0.001)** |
| **Education** | | | |
| No qualification (ref) | | | |
| Other qualification | | **0.0150 (0.008)** | **0.0140 (0.007)** |
| A level & GCSE etc | | **0.0117 (0.023)** | **0.0115 (0.015)** |
| Degree or other higher | | **0.0203 (0.000)** | **0.0193 (0.000)** |
| **Religion** | | | |
| No (ref) | | | |
| Yes | | **0.0139 (0.001)** | **0.0142 (0.000)** |
| **Overall sleep quality** | | | |
| Very good (ref) | | | |
| Fairly good | | | **-0.0485 (0.000)** |
| Fairly bad | | | **-0.0817 (0.000)** |
| Very bad | | | **-0.1455 (0.000)** |
| **GHQ-12 caseness** | | | |
| 0 (ref) | | | |
| 1-3 | | | **-0.0497 (0.000)** |
| 4 or more | | | **-0.1613 (0.000)** |

Note: all results in **bold** p<0.05; **PH** represented physical health, **DS** represented demographic & social-economics, **PF** represented psychological factors

| | | | | | | Multiple regression results-Cross-sectional correlations with SWEMWBS (p-value) 95%CI |
|---|---|---|---|---|---|---|
| **Determinants** | **T2 (PH)** | **T2 (PH+DS)** | **T2 (PH+DS+PF)** | **T3 (PH)** | **T3 (PH+DS)** | **T3 (PH+DS+PF)** |
| **R-squared (adjusted R-squared)** | **12.99% (12.93%)** | **16.53% (16.31%)** | **31.31% (31.10%)** | **15.39% (15.33%)** | **18.25% (18.03%)** | **29.71% (29.49%)** |
| **General Health** | | | | | | |
| Excellent (ref) | | | | | | |
| Very good | **-0.0365** (0.000) | **-0.0335** (0.000) | **-0.0244** (0.000) | **-0.0430** (0.000) | **-0.0390** (0.000) | **-0.0298** (0.000) |
| Good | **-0.0808** (0.000) | **-0.0719** (0.000) | **-0.0468** (0.000) | **-0.0976** (0.000) | **-0.0884** (0.000) | **-0.0606** (0.000) |
| Fair | **-0.1343** (0.000) | **-0.1165** (0.000) | **-0.0635** (0.000) | **-0.1752** (0.000) | **-0.1532** (0.000) | **-0.0878** (0.000) |
| Poor | **-0.2269** (0.000) | **-0.1940** (0.000) | **-0.0914** (0.000) | **-0.3053** (0.000) | **-0.2603** (0.000) | **-0.1443** (0.000) |
| **Chronic Disease** | | | | | | |
| No CD (ref) | | | | | | |
| 1 | **-0.0136** (0.007) | **-0.0149** (0.003) | -0.0033 (0.463) | -0.0094 (0.071) | **-0.0105** (0.043) | 0.0089 (0.064) |
| 2 | **-0.0568** (0.000) | **-0.0502** (0.000) | -0.0140 (0.169) | **-0.0331** (0.012) | -0.0232 (0.081) | -0.0014 (0.908) |
| 3-4 | **-0.0433** (0.015) | **-0.0394** (0.024) | -0.0169 (0.288) | -0.0376 (0.133) | -0.0412 (0.114) | -0.0144 (0.552) |
| 5 or more | -0.0384 (0.245) | -0.0430 (0.284) | -0.0333 (0.361) | -0.1816 (0.059) | -0.1826 (0.090) | -0.1409 (0.159) |
| **Age** | | | | | | |
| 60-62 (ref) | | | | | | |
| 63-65 | | 0.0107 (0.060) | 0.0071 (0.168) | | **0.0142** (0.041) | 0.0125 (0.053) |
| 66-68 | | **0.0195** (0.001) | **0.0117** (0.033) | | **0.0188** (0.009) | **0.0137** (0.039) |
| 69-71 | | **0.0157** (0.015) | 0.0055 (0.346) | | **0.0294** (0.000) | **0.0225** (0.001) |
| 72-74 | | **0.0236** (0.001) | **0.0152** (0.014) | | **0.0311** (0.000) | **0.0236** (0.002) |
| 75-77 | | **0.0161** (0.029) | 0.0102 (0.126) | | **0.0423** (0.000) | **0.0334** (0.000) |
| 78-80 | | 0.0009 (0.262) | 0.0022 (0.763) | | **0.0250** (0.006) | **0.0185** (0.029) |
| 81-83 | | 0.0065 (0.454) | -0.0018 (0.821) | | **0.0227** (0.028) | 0.0181 (0.060) |
| 84+ | | -0.0091 (0.284) | -0.0111 (0.149) | | 0.0084 (0.379) | 0.0051 (0.570) |
| **Sex** | | | | | | |
| Male (ref) | | | | | | |
| Female | | **-0.0142** (0.000) | 0.0046 (0.137) | | **-0.0152** (0.000) | 0.0011 (0.762) |
| **Financial situation** | | | | | | |
| Living comfortably (ref) | | | | | | |
| Doing alright | | **-0.0259** (0.000) | **-0.0205** (0.000) | | **-0.0325** (0.000) | **-0.0263** (0.000) |
| Just about getting by | | **-0.0497** (0.000) | **-0.0321** (0.000) | | **-0.0665** (0.000) | **-0.0461** (0.000) |
| Finding it quite/very difficult | | **-0.1260** (0.000) | **-0.0761** (0.000) | | **-0.1204** (0.000) | **-0.0672** (0.000) |
| **Marital Status** | | | | | | |
| Widowed (ref) | | | | | | |
| Single, Separated or Divorced | | -0.0055 (0.338) | -0.0047 (0.368) | | -0.0002 (0.981) | -0.0001 (0.993) |

| | | | | |
|---|---|---|---|---|
| Married, in a partnership or cohabit | 0.0000 (1.000) | 0.0018 (0.673) | **0.0118** (0.031) | 0.0099 (0.053) |
| **Employment Status** | | | | |
| Other inactive (including unemployed) (ref) | | | | |
| Retired | **0.0329** (0.000) | **0.0193** (0.010) | **0.0261** (0.011) | 0.0094 (0.325) |
| Employed | **0.0372** (0.000) | **0.0191** (0.017) | **0.0243** (0.020) | 0.0046 (0.634) |
| **Education** | | | | |
| No qualification (ref) | | | | |
| Other qualification | 0.0036 (0.484) | 0.0064 (0.166) | -0.0015 (0.793) | -0.0015 (0.788) |
| A level & GCSE etc | -0.0016 (0.711) | 0.0028 (0.488) | 0.0010 (0.847) | 0.0034 (0.477) |
| Degree or other higher | 0.0047 (0.302) | **0.0099** (0.017) | 0.0031 (0.555) | **0.0113** (0.023) |
| **Religion** | | | | |
| No (ref) | | | | |
| Yes | **0.0166** (0.000) | **0.0157 (0.000)** | **0.0088** (0.027) | **0.0079 (0.033)** |
| **Overall sleep quality** | | | | |
| Very good (ref) | | | | |
| Fairly good | | **-0.0360** (0.000) | | **-0.0336** (0.000) |
| Fairly bad | | **-0.0534** (0.000) | | **-0.0549** (0.000) |
| Very bad | | **-0.0680** (0.000) | | **-0.0724** (0.000) |
| **GHQ-12 caseness** | | | | |
| 0 | | | | |
| 1-3 | | **-0.0653** (0.000) | | **-0.0663** (0.000) |
| 4 or more | | **-0.2018** (0.000) | | **-0.2086** (0.000) |

Note: all results in **bold** $p<0.05$; **PH** represented physical health, **DS** represented demographic & social-economics, **PF** represented psychological factors

## 3.2 Longitudinal analysis – multilevel modelling: Fixed-effects vs Random-effects

| **SWEMWBS** | **Fixed-effects** | | | **Random-effects** | | |
|---|---|---|---|---|---|---|
| | **Coef. (SE)** | **[95% CI]** | | **Coef. (SE)** | **[95% CI]** | |
| **rho** | **0.6054** | | | **0.4109** | | |
| **General Health** | | | | | | |
| Excellent (ref) | | | | | | |
| Very good | -0.007 (0.005) | [-0.016 | 0.002] | **-0.022 (0.003)** | **[-0.028** | **-0.015]** |
| Good | **-0.020 (0.005)** | **[-0.030** | **-0.010]** | **-0.045 (0.004)** | **[-0.052** | **-0.038]** |
| Fair | **-0.037 (0.006)** | **[-0.049** | **-0.025]** | **-0.070 (0.004)** | **[-0.078** | **-0.063]** |
| Poor | **-0.065 (0.008)** | **[-0.081** | **-0.050]** | **-0.105 (0.005)** | **[-0.114** | **-0.095]** |
| **Age** | | | | | | |
| 60-62 (ref) | | | | | | |
| 63-65 | 0.006 (0.036) | [-0.002 | 0.013] | **0.008 (0.003)** | **[ 0.002** | **0.013]** |
| 66-68 | 0.007 (0.005) | [-0.002 | 0.016] | **0.011 (0.003)** | **[ 0.004** | **0.017]** |
| 69-71 | 0.004 (0.006) | [-0.007 | 0.015] | **0.011 (0.004)** | **[ 0.004** | **0.018]** |
| 72-74 | 0.005 (0.007) | [-0.008 | 0.018] | **0.014 (0.004)** | **[ 0.006** | **0.022]** |
| 75-77 | 0.003 (0.008) | [-0.013 | 0.018] | **0.012 (0.004)** | **[ 0.004** | **0.021]** |
| 78-80 | -0.004 (0.009) | [-0.021 | 0.014] | 0.007 (0.005) | [-0.002 | 0.016] |
| 81-83 | -0.014 (0.010) | [-0.034 | 0.006] | 0.005 (0.005) | [-0.005 | 0.015] |
| 84+ | **-0.027 (0.012)** | **[-0.051** | **-0.003]** | -0.009 (0.005) | [-0.020 | -0.001] |
| **Sex** | | | | | | |
| Male (ref) | | | | | | |
| Female | | | omitted | 0.004 (0.002) | [-0.001 | 0.008] |
| **Financial situation** | | | | | | |
| Living comfortably (ref) | | | | | | |
| Doing alright | **-0.012 (0.003)** | **[-0.018** | **-0.005]** | **-0.020 (0.002)** | **[-0.024** | **-0.016]** |
| Just about getting by | **-0.029 (0.004)** | **[-0.037** | **-0.020]** | **-0.036 (0.003)** | **[-0.041** | **-0.030]** |
| Finding it quite/very difficult | **-0.052 (0.006)** | **[-0.067** | **-0.038]** | **-0.064 (0.005)** | **[-0.073** | **-0.054]** |
| **Marital Status** | | | | | | |
| Widowed (ref) | | | | | | |
| Single, Separated or Divorced | **0.028 (0.011)** | **[ 0.005** | **0.050]** | -0.001 (0.004) | [-0.008 | 0.007] |
| Married, in a partnership or cohabit | **0.021 (0.008)** | **[ 0.006** | **0.037]** | **0.008 (0.003)** | **[ 0.002** | **0.015]** |
| **Employment Status** | | | | | | |
| Unpaid or Unemployed (ref) | | | | | | |
| Retired | 0.013 (0.007) | [-0.001 | 0.026] | **0.022 (0.005)** | **[ 0.012** | **0.031]** |
| Paid Employment | 0.007 (0.008) | [-0.009 | 0.022] | **0.018 (0.005)** | **[ 0.008** | **0.027]** |
| **Education** | | | | | | |
| No qualification (ref) | | | | | | |
| Other qualification | | | omitted | 0.006 (0.004) | [-0.001 | 0.013] |
| A level & GCSE etc | | | | 0.006 (0.003) | [-0.000 | 0.012] |
| Degree or other higher | | | | **0.015 (0.003)** | **[ 0.008** | **0.021]** |
| **Religion** | | | | | | |
| No (ref) | | | | | | |
| Yes | | | omitted | **0.011 (0.002)** | **[ 0.006** | **0.016]** |
| **Overall sleep quality** | | | | | | |
| Very good (ref) | | | | | | |
| Fairly good | **-0.011 (0.003)** | **[-0.017** | **-0.004]** | **-0.032 (0.002)** | **[-0.036** | **-0.028]** |
| Fairly bad | **-0.029 (0.005)** | **[-0.039** | **-0.019]** | **-0.057 (0.003)** | **[-0.063** | **-0.051]** |
| Very bad | **-0.063 (0.008)** | **[-0.078** | **-0.047]** | **-0.089 (0.005)** | **[-0.099** | **-0.079]** |
| **GHQ-12 caseness** | | | | | | |
| No evidence of probable mental illness (ref) | | | | | | |
| Less than optimal mental health | **-0.032 (0.003)** | **[-0.037** | **-0.026]** | **-0.051 (0.002)** | **[-0.055** | **-0.046]** |
| Probable psychological disturbance or mental illness | **-0.126 (0.004)** | **[-0.135** | **-0.118]** | **-0.171 (0.003)** | **[-0.177** | **-0.165]** |

Note: all results in **bold** p<0.05

## 3.3 Longitudinal analysis – multilevel modelling: Random-effects, Hausman-Taylor vs Fixed-effects

| | Random intercept | | | Random intercept & w/b effects* | | | Hausman-Taylor | | | Fixed intercept | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Est | (SE) | P value | Est | (SE) | P value | Est | (SE) | P value | Est | (SE) | P value |
| **Fixed part (β)** | | | | | | | | | | | | |
| General Health | **-0.025** | **(0.001)** | **0.000** | **-0.014** | **(0.002)** | **0.000** | **-0.017** | **(0.002)** | **0.000** | **-0.015** | **(0.002)** | **0.000** |
| Age | **0.001** | **(0.000)** | **0.006** | 0.001 | (0.001) | 0.675 | -0.001 | (0.001) | 0.509 | 0.000 | (0.001) | 0.931 |
| Sex | **0.005** | **(0.002)** | **0.024** | **0.006** | **(0.002)** | **0.006** | **0.010** | **(0.003)** | **0.000** | | | |
| Financial situation | **-0.020** | **(0.001)** | **0.000** | **-0.014** | **(0.002)** | **0.000** | **-0.016** | **(0.002)** | **0.000** | **-0.015** | **(0.002)** | **0.000** |
| Marital Status | **0.006** | **(0.001)** | **0.000** | **0.011** | **(0.004)** | **0.010** | **0.010** | **(0.002)** | **0.000** | **0.012** | **(0.004)** | **0.002** |
| Employment Status | 0.003 | (0.002) | 0.190 | -0.000 | (0.004) | 0.955 | **0.013** | **(0.003)** | **0.000** | 0.001 | (0.004) | 0.889 |
| Education | **0.004** | **(0.001)** | **0.000** | **0.002** | **(0.001)** | **0.027** | **0.008** | **(0.001)** | **0.000** | | | |
| Religion | **0.011** | **(0.002)** | **0.000** | **0.012** | **(0.002)** | **0.000** | **0.016** | **(0.003)** | **0.000** | | | |
| Overall sleep quality | **-0.030** | **(0.001)** | **0.000** | **-0.015** | **(0.002)** | **0.000** | **-0.018** | **(0.002)** | **0.000** | **-0.018** | **(0.002)** | **0.000** |
| GHQ-12 caseness | **-0.081** | **(0.001)** | **0.000** | **-0.070** | **(0.002)** | **0.000** | **-0.057** | **(0.002)** | **0.000** | **-0.057** | **(0.002)** | **0.000** |
| **[_con]** | **3.408** | **(0.008)** | **0.000** | **3.451** | **(0.009)** | **0.000** | **3.310** | **(0.014)** | **0.000** | **3.356** | **(0.012)** | **0.000** |
| **Random part** | | | | | | | | | | | | |
| **SD(_con) or ς_u** | **0.097** | | | **0.097** | | | **0.119** | | | | | |
| **SD(residual) or ς_e** | **0.134** | | | **0.133** | | | **0.129** | | | **0.130** | | |

Note: all results in **bold** p<0.05; Separate within and between effects; coefficients of cluster mean not shown

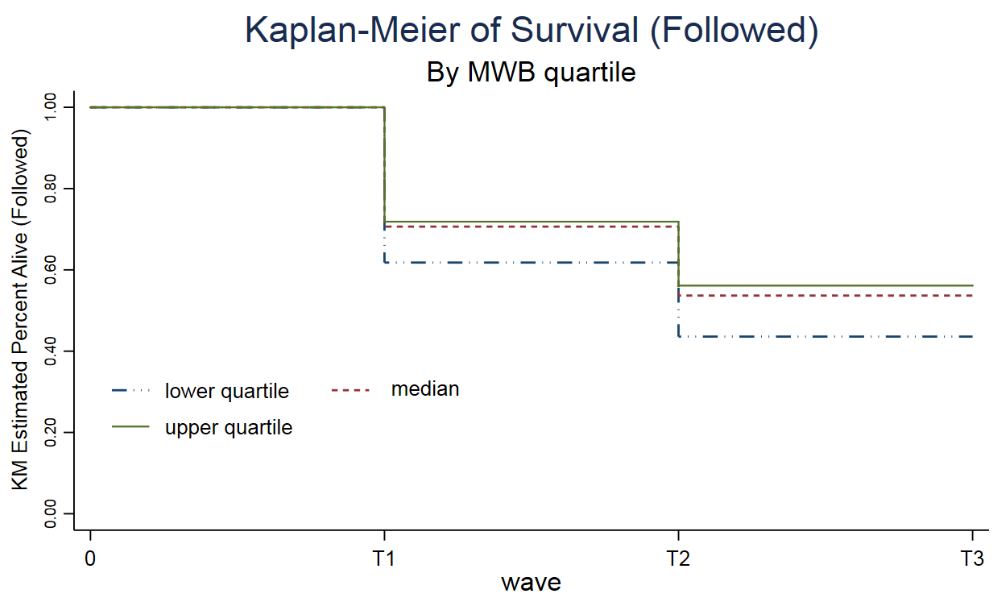
## 4. Lost to follow-up analysis

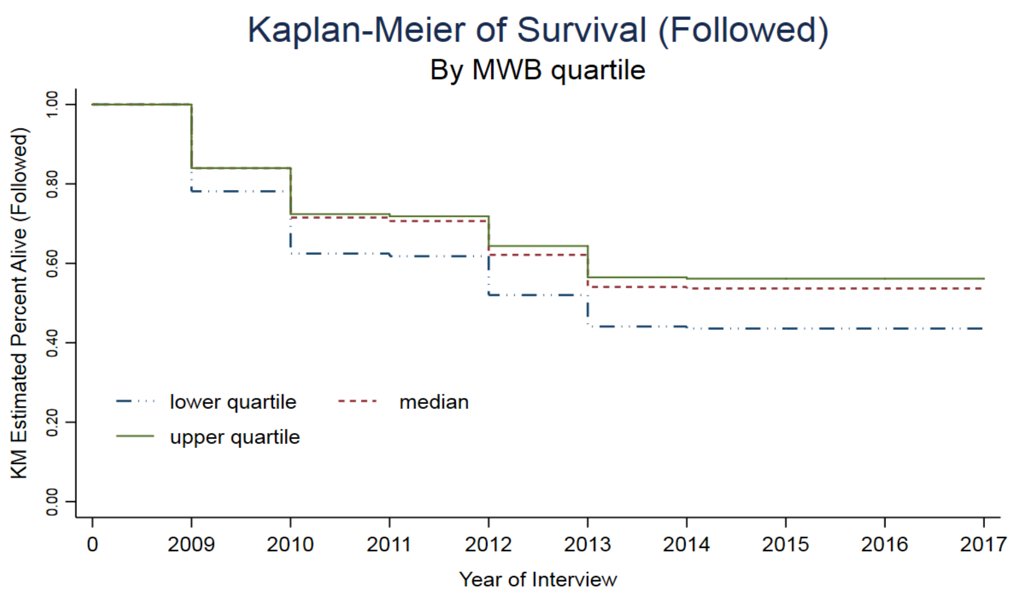
### 4.1 K-M estimations by waves and by year of interview

| Time | Begin total | Fail | Net lost | Survivor function | Std. Error | [95% CI] | |
|---|---|---|---|---|---|---|---|
| **lower quartile** | | | | | | | |
| **1** | 2526 | 965 | 0 | 0.6180 | 0.0097 | [0.5987 | 0.6366] |
| **2** | 1561 | 460 | 0 | 0.4359 | 0.0099 | [0.4164 | 0.4551] |
| **3** | 1101 | 0 | 1101 | 0.4359 | 0.0099 | [0.4164 | 0.4551] |
| **median** | | | | | | | |
| **1** | 4432 | 1301 | 0 | 0.7065 | 0.0068 | [0.6928 | 0.7196] |
| **2** | 3131 | 752 | 0 | 0.5368 | 0.0075 | [0.5220 | 0.5513] |
| **3** | 2379 | 0 | 2379 | 0.5368 | 0.0075 | [0.5220 | 0.5513] |
| **upper quartile** | | | | | | | |
| **1** | 2442 | 687 | 0 | 0.7187 | 0.0091 | [0.7004 | 0.7361] |
| **2** | 1755 | 384 | 0 | 0.5614 | 0.0100 | [0.5415 | 0.5808] |
| **3** | 1371 | 0 | 1371 | 0.5614 | 0.0100 | [0.5415 | 0.5808] |

| Time | Begin total | Fail | Net lost | Survivor function | Std. Error | [95% CI] | |
|---|---|---|---|---|---|---|---|
| **lower quartile** | | | | | | | |
| **2009** | 2526 | 552 | 0 | 0.7815 | 0.0082 | [0.7648 | 0.7971] |
| **2010** | 1974 | 396 | 0 | 0.6247 | 0.0096 | [0.6055 | 0.6433] |
| **2011** | 1578 | 17 | 0 | 0.6180 | 0.0097 | [0.5987 | 0.6366] |
| **2012** | 1561 | 247 | 0 | 0.5202 | 0.0099 | [0.5005 | 0.5395] |
| **2013** | 1314 | 200 | 0 | 0.4410 | 0.0099 | [0.4216 | 0.4603] |
| **2014** | 1114 | 13 | 0 | 0.4359 | 0.0099 | [0.4164 | 0.4551] |
| **2015** | 1101 | 0 | 562 | 0.4359 | 0.0099 | [0.4164 | 0.4551] |
| **2016** | 539 | 0 | 512 | 0.4359 | 0.0099 | [0.4164 | 0.4551] |
| **2017** | 27 | 0 | 27 | 0.4359 | 0.0099 | [0.4164 | 0.4551] |
| **median** | | | | | | | |
| **2009** | 4432 | 711 | 0 | 0.8396 | 0.0055 | [0.8284 | 0.8501] |
| **2010** | 3721 | 551 | 0 | 0.7153 | 0.0068 | [0.7017 | 0.7283] |
| **2011** | 3170 | 39 | 0 | 0.7065 | 0.0068 | [0.6928 | 0.7196] |
| **2012** | 3131 | 377 | 0 | 0.6214 | 0.0073 | [0.6069 | 0.6355] |
| **2013** | 2754 | 358 | 0 | 0.5406 | 0.0075 | [0.5258 | 0.5552] |
| **2014** | 2396 | 17 | 0 | 0.5368 | 0.0075 | [0.5220 | 0.5513] |
| **2015** | 2379 | 0 | 1180 | 0.5368 | 0.0075 | [0.5220 | 0.5513] |
| **2016** | 1199 | 0 | 1140 | 0.5368 | 0.0075 | [0.5220 | 0.5513] |
| **2017** | 59 | 0 | 59 | 0.5368 | 0.0075 | [0.5220 | 0.5513] |
| **upper quartile** | | | | | | | |
| **2009** | 2442 | 391 | 0 | 0.8399 | 0.0074 | [0.8247 | 0.8538] |
| **2010** | 2051 | 283 | 0 | 0.7240 | 0.0090 | [0.7058 | 0.7413] |
| **2011** | 1768 | 13 | 0 | 0.7187 | 0.0091 | [0.7004 | 0.7361] |
| **2012** | 1755 | 183 | 0 | 0.6437 | 0.0097 | [0.6244 | 0.6624] |
| **2013** | 1572 | 193 | 0 | 0.5647 | 0.0100 | [0.5448 | 0.5841] |
| **2014** | 1379 | 8 | 0 | 0.5614 | 0.0100 | [0.5415 | 0.5808] |
| **2015** | 1371 | 0 | 684 | 0.5614 | 0.0100 | [0.5415 | 0.5808] |
| **2016** | 687 | 0 | 652 | 0.5614 | 0.0100 | [0.5415 | 0.5808] |
| **2017** | 35 | 0 | 35 | 0.5614 | 0.0100 | [0.5415 | 0.5808] |

## 4.2 K-M curve of follow-up by waves and by years of interview



## 4.3 Cox regression MWB on survival by waves and by years

| | By waves | | By years | |
|---|---|---|---|---|
| | **HR (P-value)** | **95% CI** | **HR (P-value)** | **95% CI** |
| **MWB quartile** | | | | |
| lower (ref) | | | | |
| median | **0.7842 (0.000)** | **[0.7329 0.8390]** | **0.7617 (0.000)** | **[0.7119 0.8149]** |
| upper | **0.7378 (0.000)** | **[0.6816 0.7987]** | **0.7141 (0.000)** | **[0.6596 0.7730]** |

**Cox regression full estimation**

| | By waves | | By years | |
|---|---|---|---|---|
| | **HR (P-value)** | **95% CI** | **HR (P-value)** | **95% CI** |
| **MWB quartile** | | | | |
| lower (ref) | | | | |
| median | **0.9024** (0.007) | **[0.8378 0.9720]** | **0.8868 (0.002)** | **[0.8234 0.9551]** |
| upper | **0.8767** (0.004) | **[0.8015 0.9590]** | **0.8603 (0.001)** | **[0.7865 0.9409]** |
| **General Health** | | | | |
| Excellent (ref) | | | | |
| Very good | 1.0338 (0.568) | [0.9222 1.1590] | 1.0372 (0.531) | [0.9253 1.1627] |
| Good | 1.1202 (0.054) | [0.9979 1.2575] | **1.1242 (0.047)** | **[1.0015 1.2619]** |
| Fair | **1.3192** (0.000) | **[1.1654 1.4934]** | **1.3557 (0.000)** | **[1.1979 1.5343]** |
| Poor | **1.5918** (0.000) | **[1.3785 1.8382]** | **1.6820 (0.000)** | **[1.4569 1.9419]** |
| **Chronic Disease** | | | | |
| No CD (ref) | | | | |
| 1 | 0.9685 (0.453) | [0.8909 1.0529] | 0.9616 (0.359) | [0.8846 1.0455] |
| 2 | 0.9612 (0.412) | [0.8745 1.0565] | 0.9509 (0.296) | [0.8652 1.0451] |
| 3-4 | 0.9426 (0.268) | [0.8491 1.0464] | 0.9220 (0.128) | [0.8305 1.0237] |
| 5 or more | 1.0384 (0.630) | [0.8909 1.2103] | 1.0242 (0.760) | [0.8787 1.1938] |
| **Age** | | | | |
| 60-62 (ref) | | | | |
| 63-65 | 1.0055 (0.920) | [0.9027 1.1201] | 1.0007 (0.989) | [0.8983 1.1148] |
| 66-68 | 1.1140 (0.065) | [0.9933 1.2495] | 1.1204 (0.052) | [0.9989 1.2567] |
| 69-71 | **1.2120** (0.001) | **[1.0771 1.3640]** | **1.2300 (0.001)** | **[1.0931 1.3841]** |
| 72-74 | **1.2042** (0.004) | **[1.0625 1.3648]** | **1.2146 (0.002)** | **[1.0716 1.3766]** |
| 75-77 | **1.4330** (0.000) | **[1.2577 1.6327]** | **1.4836 (0.000)** | **[1.3021 1.6904]** |
| 78-80 | **1.5099** (0.000) | **[1.3164 1.7319]** | **1.5683 (0.000)** | **[1.3674 1.7987]** |
| 81-83 | **1.7053** (0.000) | **[1.4681 1.9809]** | **1.8218 (0.000)** | **[1.5683 2.1162]** |
| 84+ | **2.1855** (0.000) | **[1.8963 2.5189]** | **2.4648 (0.000)** | **[2.1383 2.8412]** |
| **Sex** | | | | |
| Male (ref) | | | | |
| Female | 0.9453 (0.077) | [0.8881 1.0061] | 0.9440 (0.070) | [0.8870 1.0047] |
| **Subjective financial situation** | | | | |
| Living comfortably (ref) | | | | |
| Doing alright | 1.0301 (0.424) | [0.9579 1.1077] | 1.0338 (0.370) | [0.9613 1.1117] |
| Just about getting by | **1.0994 (0.018)** | **[1.0167 1.1889]** | **1.1146 (0.007)** | **[1.0307 1.2052]** |
| Finding it quite/very difficult | 1.0701 (0.333) | [0.9330 1.2273] | 1.0750 (0.301) | [0.9374 1.2329] |
| **Marital Status** | | | | |
| Widowed (ref) | | | | |
| Single, Separated or Divorced | 1.0132 (0.807) | [0.9121 1.1255] | 1.0188 (0.729) | [0.9171 1.1316] |
| Married, in a partnership or cohabit | 1.0259 (0.541) | [0.9451 1.1135] | 1.0337 (0.428) | [0.9524 1.1219] |
| **Employment Status** | | | | |
| Unpaid or Unemployed (ref) | | | | |
| Retired | 0.9660 (0.621) | [0.8422 1.1080] | 0.9479 (0.444) | [0.8263 1.0872] |
| Paid Employment | 0.9637 (0.633) | [0.8281 1.1215] | 0.9482 (0.491) | [0.8148 1.1034] |
| **Education** | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| No qualification (ref) | | | | | | |
| Other qualification | **0.9000 (0.014)** | **[0.8274** | **0.9789]** | **0.8881 (0.006)** | **[0.8165** | **0.9660]** |
| A level & GCSE etc | **0.8463 (0.000)** | **[0.7808** | **0.9172]** | **0.8284 (0.000)** | **[0.7643** | **0.8978]** |
| Degree or other higher | **0.7338 (0.000)** | **[0.6732** | **0.8001]** | **0.7114 (0.000)** | **[0.6526** | **0.7755]** |
| **Religion** | | | | | | |
| No (ref) | | | | | | |
| Yes | 1.0127 (0.705) | [0.9484 | 1.0814] | 1.0100 (0.766) | [0.9459 | 1.0785] |
| **Overall sleep quality** | | | | | | |
| Very good (ref) | | | | | | |
| Fairly good | 0.9675 (0.361) | [0.9014 | 1.0385] | 0.9666 (0.347) | [0.9006 | 1.0375] |
| Fairly bad | 0.9697 (0.555) | [0.8753 | 1.0742] | 0.9641 (0.484) | [0.8703 | 1.0680] |
| Very bad | 0.9252 (0.354) | [0.7850 | 1.0905] | 0.9294 (0.382) | [0.7888 | 1.0951] |
| **GHQ-12 caseness** | | | | | | |
| No evidence of probable mental illness (ref) | | | | | | |
| Less than optimal mental health | 1.0188 (0.621) | [0.9464 | 1.0967] | 1.0262 (0.492) | [0.9533 | 1.1048] |
| Probable psychological disturbance or mental illness | 1.0265 (0.589) | [0.9337 | 1.1284] | 1.0339 (0.489) | [0.9406 | 1.1365] |

# APPENDIX D. ETHICS

B BSREC,Resource
Thu 07/07

Hi

If the data you wish to analyse is already **publicly** available then you do not need ethical approval for your study.

If the data is not available to the public then you will need BSREC light touch approval.

BW
Emily

Wang, Ariel
30/06/2016
BSREC,Resource

Reply all

Sent Items

Hi,

I'm a first PhD student at the medical school. My research is on the epidemiology of mental well-being in older people. It will involves in quantitative analyse of three UK national survey datasets. The datasets I intends to use are: the Health Survey England 2011-2012; Understanding Society wave 3 (2009-2012); and English Longitudinal Study of Ageing wave 1-6 (2002-2012). All datasets are public datasets. I don't need to collect any data by myself. However, my supervisor said that I still need to get ethical review or approval from the BSREC. I don't really know how should I do it. I found the following statement but I still need you kindly help on it. Thank you very much

**BSREC Project/Study Triaging**

**a) BSREC does not require ethical review for:**

1. Secondary analysis of published or publically available data, e.g. meta-analyses and literature reviews;