The role of social participation in maintaining mental and physical health in older people with musculoskeletal pain

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ABSTRACT

Background

Identifying factors that distinguish between older people with chronic musculoskeletal pain who maintain good mental and physical health, and those who do not, would inform practical programmes for promoting future physical and mental health in the many people with this condition. Social participation is one such potential factor. It is associated with lower levels of disabling musculoskeletal pain and better health in older people. There have been no longitudinal studies designed to investigate whether this is a causal association or not. This thesis uses data from a well-established UK prospective cohort study to investigate the hypothesis that active social participation is one determinant of the capacity of older people with musculoskeletal pain to maintain future physical and mental health.

Methods

After an initial systematic review, secondary analyses were performed on publicly available data using samples from a nationally representative cohort study initiated in 2002 among 12,099 adults aged ≥50 years (the English Longitudinal Study of Ageing (ELSA)). ELSA provided baseline measures relevant to the study hypothesis, and multiple follow-up time-points for longitudinal causal pathway analyses. Using a novel latent class analysis approach, individuals grouped by similar social participation activities were identified in ELSA at different follow-up points. Longitudinal regression models explored whether social participation: i) explained (effect mediation), ii) identified who experienced (effect modification), or iii) obscured (confounded), the relationship between baseline pain and future mental/physical health in ELSA participants.

Results

The systematic review found no papers addressing whether participation determines which older people with musculoskeletal pain maintain their health. In ELSA, baseline musculoskeletal pain

was associated with reduced mental and physical health two years later (OR = 0.24 and 0.35 respectively), and those reporting high social participation were more likely to report future good physical health (OR = 3.40; 95%CI: 2.90-3.98) and mental health (OR=2.40; 95%CI: 2.05-2.84), compared with people with infrequent participation, independent of musculoskeletal pain. In people with pain, however, and after adjustment for confounders, active social participation had only a weak effect on future mental health (OR= 1.46; 95%CI: 1.12-1.91) and no effect on physical health. Two individual components of social participation ('sense of purpose' and 'physical activity'), although less common in persons with chronic musculoskeletal pain, did, after adjustment, predict future good health in such people, both mental (OR sense of purpose=3.95; 95%CI: 2.84-5.35) and physical (OR for sense of purpose=2.01; 95%CI: 1.54-2.60; OR for physical activity=1.57; 95%CI:1.19-2.05).

Conclusion

Current public health messages of the potential positive consequences for older people's health of promoting active social participation are consistent with the results of the overall analyses of ELSA presented in this thesis. However, new evidence from this thesis suggests this would not directly contribute to maintaining future physical and mental health in older people with chronic musculoskeletal pain. Rather, the thesis has provided observational epidemiological evidence to support development of interventions targeting individual components of social participation (sense of purpose and physical activity) to research whether they could help maintain future mental and physical health in older people with musculoskeletal pain as part of pain management programmes.

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LIST OF ABBREVIATIONS

aBIC	Adjusted Bayesian Information Criterion
AIC	Akaike Information Criterion
APHO	Association of Public Health Observatories
B	Beta coefficient
BIC	Bayesian Information Criterion
BLRT	Bootstrapped parametric likelihood ratio test
CI	Confidence Interval
CSDH	Conceptual Framework for Action on the Social Determinants of Health
DAGS	Directed Acyclic Graphs
FreqHigh	Frequent socialisers with high levels of social engagement
FreqLow	Frequent socialisers with low levels of social engagement
HPA	hypothalamic-pituitary-adrenal
LCA	Latent Class Analysis
ML	Maximum likelihood
MOS-36	Medical Outcome Study Short Form-36
MSK	Musculoskeletal
NICE	The National Institute for Health and Care Excellence
ONS	Office of National Statistics
OR	Odds ratio
RR	Relative risk ratio
RW	Dr Ross Wilkie (Lead Supervisor)
SB	Shula Baker (Doctoral candidate)
SE	Standard error
SP	Social participation
SPSS	Statistics Package for Social Sciences
VIF	Variance inflation factor

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CHAPTER ONE: INTRODUCTION

1.1 CHAPTER OVERVIEW

The research described in this thesis has the overall aim to investigate the role of social participation in maintaining health in older people with musculoskeletal pain. This chapter introduces the thesis with a brief background rationale (developed in more detail in Chapter 2), states the overall research aim and objectives, and summarises the structure of the thesis.

1.2 STUDY RATIONALE

Chronic pain (pain that persists beyond the immediate injury or damage that initially provokes it) is increasingly seen as a condition in its own right (Blyth et al., 2015) and linked with restrictions on an individual's general mental and physical health and on their capacity to participate in daily life. Such pain is common, estimated to affect about one-in-three adults worldwide in any one year (VanDenKerkhof et al., 2015)). The dominant category of chronic pain is musculoskeletal pain, i.e. pain perceived to arise in joints, muscles, bones and related soft tissues. Chronic musculoskeletal pain conditions, such as back and neck pain and osteoarthritis, are now recognised as the leading cause globally of years spent living with disability (GBD, 2016). In this thesis musculoskeletal pain has been selected as the focus of interest to investigate the nature of links between social participation and mental and physical health in persons with chronic pain.

Pain generally, and musculoskeletal pain in particular, is a risk factor for subsequent ill-health (Jordan, et al., 2007; Dawson, et al., 2005), and associated with an increased prevalence of physical conditions including cancer, gastrointestinal disorders and cardiovascular disease (Tilley et al., 2015;Dominick et al., 2012;Caughey et al., 2010;McBeth et al., 2009). Musculoskeletal pain is also associated with double the risk of depression (Dominick, et al., 2012; Blay, et al., 2012). Its impact on daily life increases with age (Thomas, et al., 2004) and older people with musculoskeletal pain represent a group with additional risk of poor health outcomes (Christensen, et al., 2009).

However, not all older people reporting musculoskeletal pain experience an associated deterioration in mental and physical health. Of those older people with interfering musculoskeletal pain (i.e. impedes daily activities) and/or widespread pain, an estimated 38% continue to maintain mental and physical health (Jordan, et al., 2012). The deterioration in health often attributed to musculoskeletal pain in older people therefore is not inevitable. Greater understanding of attributes or factors that determine which individuals with common chronic conditions, such as chronic musculoskeletal pain, maintain health is important in planning and resourcing support for older people to live well.

One factor that might be involved in the maintenance of mental and physical health in people with persistent musculoskeletal pain is 'social participation'. Social participation refers to any activities that involve interaction with others and fulfilment of aspects of an individual's social roles (e.g. being a worker, carer or community member) (Levasseur et al., 2010). It is known to be associated generally with the maintenance of health in older people (Cornwell & Waite, 2012;Barth et al., 2010;Forsman et al., 2011) and lower social participation is associated with musculoskeletal pain and poor health outcomes in older people (Wilkie et al., 2016;Wilkie et al., 2013;Umberson & Montez, 2010;Uchino & Kazdin, 2011). However, little is currently known about its specific role in older people with musculoskeletal pain. The studies in this thesis are concerned with examining the role of social participation in determining which older people with musculoskeletal pain maintain mental and physical health.

In epidemiological terms, the role of social participation in determining this association may be that of 1) an effect mediator, 2) an effect modifier, or 3) a confounder. These three roles are illustrated in Figure 1.1 below and described in more detail in Chapter Three. An effect mediator (or pathway variable) is a third variable which is on the pathway between an exposure and an outcome, and explains part, or all, of an observed effect between the exposure and outcome (Szklo & Nieto, 2014). An effect modifier identifies subgroups in which differing levels of effect are observed between the exposure and the outcome (Szklo & Nieto, 2014), and a confounding variable is a third variable not on the causal pathway between the exposure and outcome, but which can distort the true effect if unevenly distributed across the groups being compared (Szklo & Nieto, 2014). The studies in this thesis are concerned to investigate whether social participation has any of these three roles in the maintenance of mental and physical health in older people with musculoskeletal pain.

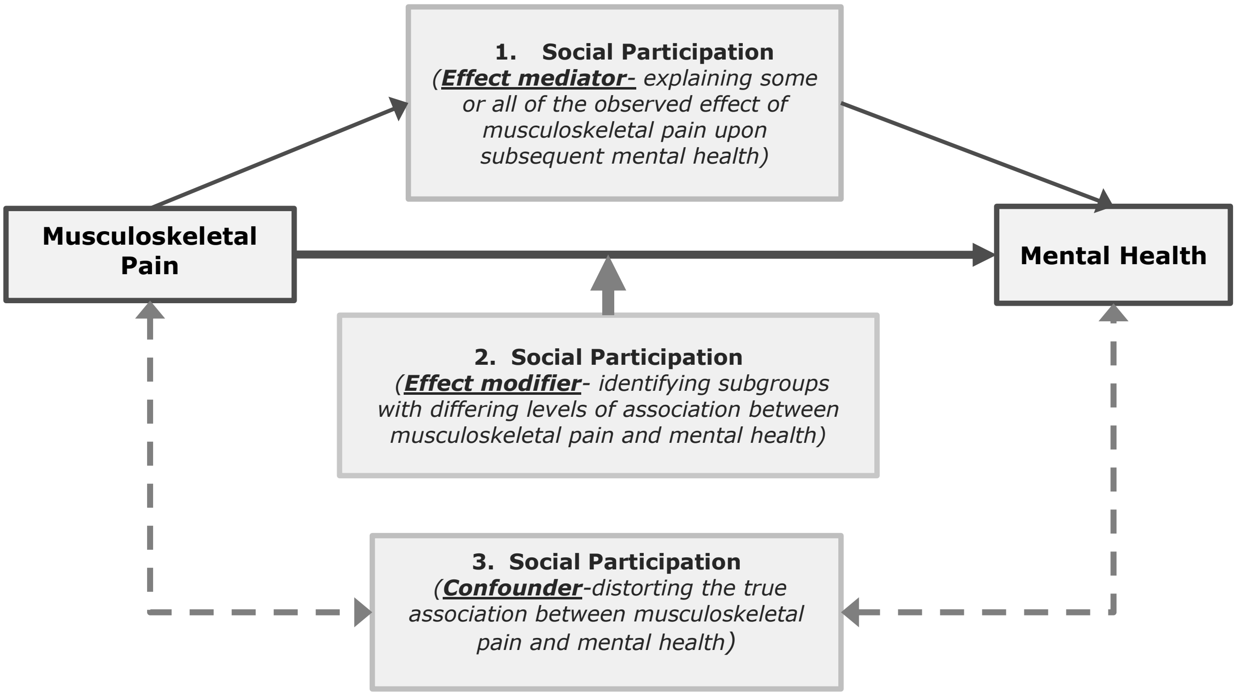


Figure 1:1 The possible roles social participation may fulfil in determining the association of musculoskeletal pain upon mental health in older people

1.3 THESIS AIM AND OBJECTIVES

The overall aim of the research reported in this thesis was to determine the role or roles of social participation in maintaining mental and physical health, in older people with musculoskeletal pain. The findings will contribute new knowledge about the role of social participation in supporting healthy ageing, specifically in relation to the presence of musculoskeletal pain in particular, and inform future management strategies to improve health outcomes in older people with musculoskeletal pain. The following research objectives were developed and addressed to fulfil the thesis aim:

1. To identify existing empirical evidence examining social participation as an effect mediator or effect modifier of associations between musculoskeletal pain and mental and/or physical health conditions in older people.

2. To use latent class analysis to define groups of older people who share similar social participation characteristics; this definition will be used in subsequent analyses to examine the role of social participation in older people with musculoskeletal pain.

3. To investigate the role of social participation in determining the association between musculoskeletal pain and subsequent mental and physical health in older people by testing the following distinctive hypotheses:
    a. social participation is an effect mediator of the association between musculoskeletal pain and subsequent mental health in older people;
    b. social participation is an effect modifier of the association between musculoskeletal pain and subsequent mental health in older people;
    c. social participation is a confounding variable, distorting the true association between musculoskeletal pain and subsequent mental health in older people.
4. To investigate the role of social participation in determining the association between musculoskeletal pain and physical health in older people by empirically testing the hypotheses described in objectives 4a-c, using physical health as the outcome of interest.

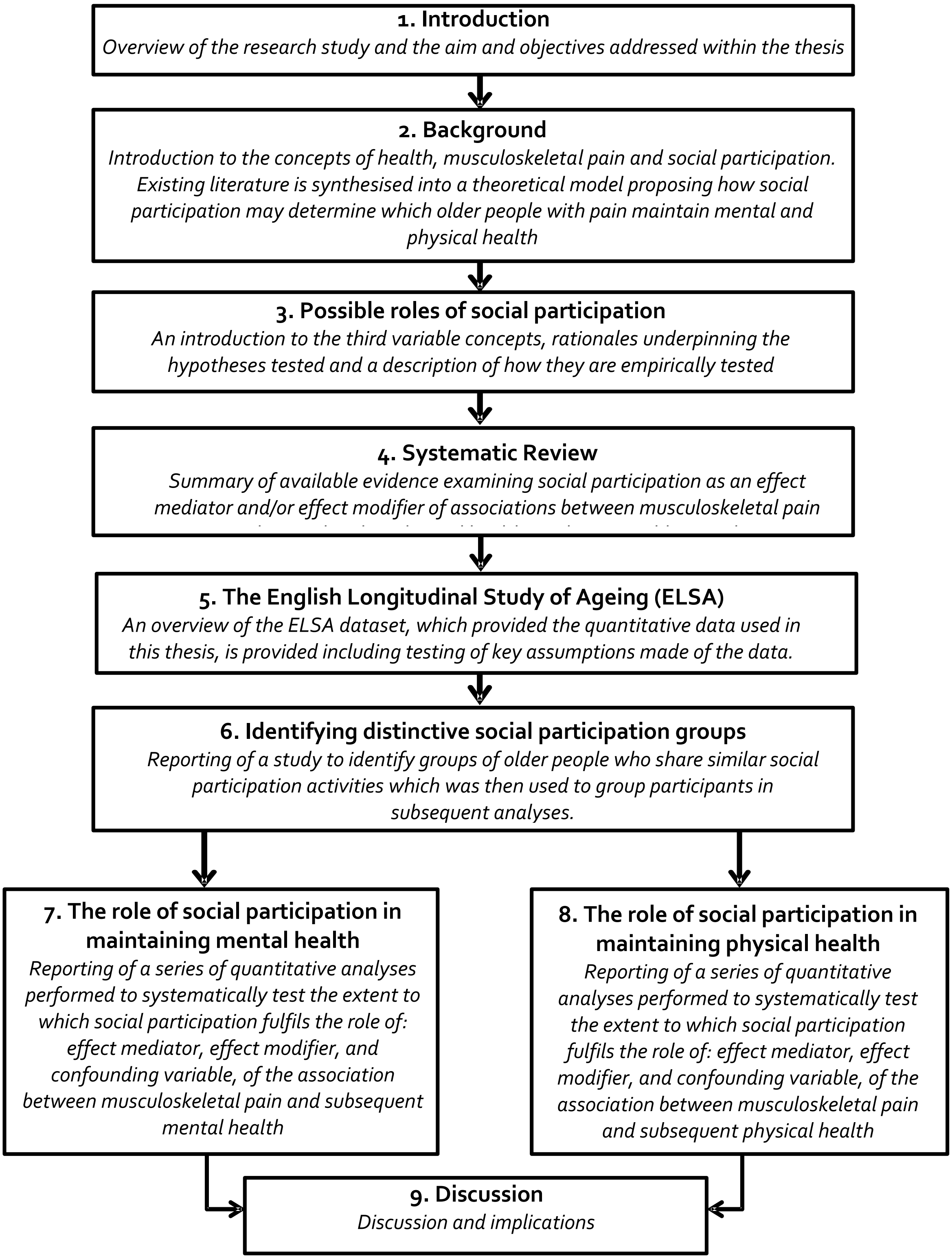


Figure 1:2 Overview of the thesis

CHAPTER TWO: BACKGROUND

2.1 CHAPTER OVERVIEW

This chapter provides a background to the study, and introduces concepts important to the research topic, including social participation. It presents a practical model for describing how social participation may determine which older people with musculoskeletal pain maintain their health and for developing the analyses described in the thesis.

2.1.1 THESIS STUDY POPULATION

This study focusses on the general older population. There is no universally agreed way to define older people, because what is meant by 'old age' differs according to the context (e.g. chronological age, biological age, societal expectations). The United Nations has agreed that 60+ years is the usual cut-off for old age, while the World Health Organisation has used 50+ for a study of ageing in Africa (Kowal & Peachey, 2001). For the purpose of this thesis older people are defined as those aged ≥50 years. This is the criterion applied in the English Longitudinal Study of Ageing (Steptoe et al., 2012), from which the data for quantitative analyses in this thesis have been drawn.

Older people represent a significant proportion of the UK general population. There are over 23.6 million people aged 50 years and over in the UK, representing over a third of the total UK population (ONS, 2016). Older people are the main users of health and social care services in the UK (APHO, 2008), which are often situated in primary care. Primary care encompasses all healthcare taking place outside acute and mental health trusts (NHS digital,2015). A priority for public health and primary care providers is to promote health in older people, and to help maintain health in those with existing conditions (Chew-Graham et al., 2016; APHO, 2008; Age Concern, 1998). As the number of older people in the UK increases due to rising life expectancy, a major concern of public health and primary care providers is that increased longevity is currently not accompanied by an increase in active and healthy ageing (APHO, 2008). Common painful musculoskeletal conditions, such as back and neck pain and osteoarthritis, that dominate global burden of disease estimates of years lived with disability in older people (GBD, 2016), pose a particular challenge in this regard. Yet there is evidence that some older people with chronic musculoskeletal pain can achieve and maintain good levels of self-reported mental and physical health (Jordan et al., 2012; Goubert & Trompetter., 2017). This thesis sets out to examine if and how one factor, social participation (defined as fulfilment of social roles and participating in social activities), is associated with long-term maintenance of health in older people with musculoskeletal pain.

2.2 HEALTH IN OLDER PEOPLE

2.2.1 HEALTHY AGEING

Ageing is characterised by a multifaceted and complex progression and accumulation of biological, psychological, and social changes in a person (Binstock & George, 2011). Many chronic conditions become more common in older people, including musculoskeletal disorders (e.g. osteoarthritis), depression and cardiovascular disease (Luppa et al., 2012; Craig et al., 2005b; Wolff et al., 2002). Consequently, maintaining health can become more challenging in older age as health conditions begin to accumulate.

The traditional biomedical model of health defines health as contingent upon the absence of disease (Nettleton, 2006). For many older people the reality is that pathophysiological changes and chronic health conditions are part of ageing (Tan, et al., 2015), yet 56% of those aged ≥65 years still report good or very good health (Craig, et al., 2005a). Advances in healthcare and science now enable people with chronic health conditions to live longer, and with a better quality of life, than before (Wade & Halligan, 2004). The 'healthy ageing' model is increasingly used to conceptualise desirable health outcomes in older age within the fields of health and gerontology (e.g. Stephens et al., 2015;Wilkie et al., 2013;Holmes & Joseph., 2011). The model is notable because it does not assume that those with existing health conditions cannot be 'healthy'. Rather than focussing on ageing in the absence of disease, healthy ageing seeks to optimise an older person's health and wellbeing in a way which acknowledges, but is not predetermined by, any disease or pathology. Healthy ageing focusses on minimising the risk and impact of disease and disability, and maintaining mental and physical health and continued engagement with life (Stephens et al., 2015; Birchera & Kuruvilla., 2014; AgeUK, 2014). Viewing health and disease pathology as two distinct concepts allows a focus on maintaining and restoring *health* even in those with chronic conditions or pathophysiological changes. This viewpoint underpins this thesis as it examines the role of social participation in determining which older people with musculoskeletal pain maintain mental and physical health.

2.2.2 DETERMINANTS OF HEALTH IN OLDER AGE

Mechanisms underlying the maintenance of health are complex and multi-dimensional. Many factors and individual characteristics influence health in older age, and are associated with inequalities in health outcomes. Some are characteristics accumulated across the life-course such as lifestyle choices (smoking habits, diet, exercise) and levels of education and poverty (Binstock & George, 2011; Heikkinen, 2003). Others are non-modifiable factors such as ethnicity and gender, which can also create barriers to health and wellbeing in later life (Luppa et al., 2012; Heikkinen, 2003). Social factors, ranging from community level (e.g. local health policies and cultural and social norms) to personal level (e.g. social network size, social activities and socioeconomic status) also play a role in determining health (Braveman & Gottlieb., 2014; WHO., 2010). The Meikirch Model of Health offers one construct of health as the state when biologically and personally acquired abilities are able to satisfy the demands of life (Birchera & Kuruvilla, 2014). These abilities are influenced by individual, social and environmental factors (Figure 2:1).

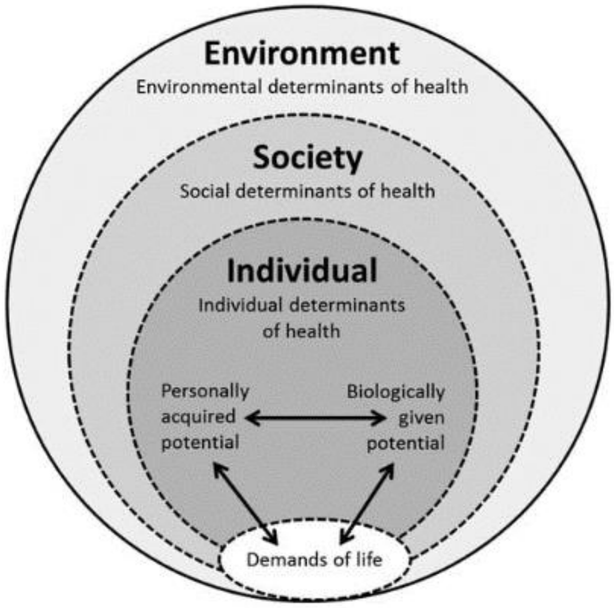


Figure 2:1 The Meikirch Model of Health: showing the different levels of health determinants and how they influence health. Source: Birchera & Kuruvilla (2014)[1]

[1] Figure 1 page 369 in Birchera & Kuruvilla (2014).

The Meikirch model does not centre around disability, but instead focuses on maintaining health. The model identifies health as arising from the interrelationship between demands of life, personally acquired characteristics (e.g. socioeconomic status and lifestyle factors) and biologically given factors (e.g. genetically determined or congenital characteristics), nested within society and their environment. 'Demands of life' are sources of stress and adversity, and range from the loss of a loved one to chronic illnesses such as musculoskeletal pain (Hildon, et al., 2008). Later life is a period in which such stress and adversity often becomes more frequent (Binstock & George, 2011; Hildon, et al., 2008). Consequently, maintaining health can become more challenging in older age as both demands of life and health conditions begin to accumulate. This has driven health policy and primary care priorities towards health promotion, maintaining health and wellbeing in those with existing conditions, and reducing the onset of secondary health problems (Oliver et al., 2014; HM Government, 2010b). Pain is one such common health condition, estimated to affect between 35.0% to 51.3% of the UK population, and a risk factor for future ill health (Gabriel & Michaud, 2009). A need for further research specifically targeting the pain management and healthcare needs of older people with pain has been highlighted as a priority by Gibson (Gibson 2006).

2.3 MUSCULOSKELETAL PAIN IN OLDER PEOPLE

2.3.1 WHAT IS PAIN?

Pain is as 'an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage' (IASP, 1994), and is a ubiquitous part of life for people of all ages and populations. The purpose of pain is to prevent and protect an individual from sustaining injury or harm (IASP, 1994). Pain signals are relayed in response to stimuli from peripheral and visceral tissues to the brain via the central nervous system, obtruding into an individual's conscious awareness to alert them to perceived or actual tissue damage.

Pain often resolves once the noxious stimulus ceases or is removed and the body has healed, but occasionally it may persist. This pain, which lasts beyond the expected healing period, is referred to as 'chronic' or 'persistent' pain (BPS, 2014). Pain which resolves more quickly is categorised as 'acute' pain (BPS, 2014). There is no established time period for 'expected healing', although pain which persists beyond three months is generally accepted as being persistent or chronic (Siddall & Cousins, 2004). Sometimes no expected healing time may exist, for example pain arising from chronic conditions such as hip osteoarthritis may require surgical intervention to be resolved (i.e. joint replacement surgery). An individual's interpretation of pain is highly subjective, and can be influenced by environmental, individual and affective factors (Cairncross et al., 2007; Wall, 1999).

Chronic pain is associated with the occurrence of functional and structural changes in the neuromuscular system, causing many to view it as a health condition in its own right (Croft et al., 2010;Niv & Devor, 2004). The experience of pain induces an autonomic response known as the fight-or-flight response (Wall, 1999). The fight-or-flight response primes the body for physical exertion, diverting resources from other less essential functions such as digestion or resting to the cardiovascular system. In the case of chronic pain, the vascular and endocrine systems may maintain their emergency state, leading an individual to experience detrimental effects from prolonged stress. A wide array of physiological and behavioural functions can be affected by prolonged pain including emotion, vigilance, memory, sleep patterns and digestion (Wall, 1999). Consequently, chronic pain can be studied using concepts and ideas from classical epidemiology in the same way as other chronic health conditions (Croft et al., 2010).

This study is concerned with musculoskeletal pain, which may arise from acute injuries to the body (e.g. bone fractures, muscular strains or joint sprains), or be secondary to another health condition or musculoskeletal system dysfunction (e.g. tendinitis and osteoporosis), and is the most common type of chronic pain (Rustøen et al., 2005). Musculoskeletal disorders account for around £5 billion of NHS spending in England, making it the fourth largest programme budget component (ARUK, 2013). Musculoskeletal pain can exacerbate existing health problems and is acknowledged as a leading cause of disability and ill health in older people (Palazzo et al., 2014), and common syndromes of musculoskeletal pain such as back and neck pain and osteoarthritis are recognised as the leading cause globally of years lived with disability (GBD, 2016). Patients with musculoskeletal pain are also more likely to consult primary care about non-musculoskeletal problems than patients without pain (Kadam et al., 2005).

2.3.2 DEFINING MUSCULOSKELETAL PAIN IN THIS THESIS

In this thesis, the term 'musculoskeletal pain' is used to refer to pain which arises from the musculoskeletal system. As not all older people have definitive diagnoses for the source of their pain, many health surveys and epidemiological studies assume that most chronic or persistent pain reported in the general older population is musculoskeletal in origin (e.g. Wilkie et al., 2013; Parsons et al., 2006). There is empirical evidence that musculoskeletal conditions are indeed the most common cause of pain in older people

(Henderson et al., 2013; Croft et al., 2010). A general population survey of adults comparing reported pain with reported diagnoses found that 90% of chronic pain is attributed to musculoskeletal disorders or localised to the musculoskeletal system (Andersson et al., 1993). Other surveys since then have confirmed that musculoskeletal pain, especially joint pain and back pain in older people, is the dominant single type of chronic pain in general population samples from a range of countries (studies include Elliott et al 1999, Thomas et al 2004, Demyttenaere et al 2007, van der Windt et al 2008, Wong and Fielding 2011, Inoue et al 2015, Rapo-Pylkkö et al 2016, Pereiera et al 2017). Even in the last years of life, among older people with a range of diagnoses underlying terminal illness, the commonest cause of their pain is musculoskeletal (Smith et al 2010).

This thesis is focussed on musculoskeletal pain as the commonest and most disabling example of the population health problem of chronic pain in older people. At some points in the thesis, citations are provided of studies which did not explicitly test or define the pain as 'musculoskeletal pain', yet provide important information or evidence pertinent to the body of work. Therefore, **in this thesis the term 'pain' is used to refer to pain assumed to be predominantly musculoskeletal in origin, but for which the source of pain is not explicitly captured or provided.** For example, in epidemiological surveys using manikins to capture pain in community dwelling older people, the diagnosis of such pain is not clarified, but it can be assumed, based upon previous research, that the majority of pain identified is musculoskeletal in origin (Croft et al., 2010;van der Hoven et al., 2010). Finally, **pain which is not explicitly or implicitly known to be musculoskeletal in origin is cited in terms consistent with the source of the pain** (e.g. 'cancer pain'). In the quantitative analyses reported later in the thesis the assumption that the measure of pain used in the ELSA analyses represents musculoskeletal pain is empirically tested (details of these tests are provided in Chapter Five).

2.3.3 MUSCULOSKELETAL PAIN IN OLDER PEOPLE

Based upon the assumption that 90% of chronic pain is musculoskeletal pain (Andersson et al., 1993), general population surveys capturing persistent and chronic pain provide information on the prevalence and trends of musculoskeletal pain. Such large national and international population studies suggest musculoskeletal pain prevalence rises with age (Steptoe et al., 2015; Fejer & Ruhe, 2012; Schopflocher et al., 2011) but plateaus around the seventh decade and then remains more or less constant (Fejer & Ruhn, 2012; Jakobsson, 2010). The prevalence of musculoskeletal pain that interferes with life by contrast continues to rise into the very oldest age-groups (Thomas et al., 2004). Wide variations in prevalence are often found due to differences in definition and methods between studies (Abdulla et al., 2013;Fejer & Ruhe, 2012;Schopflocher et al., 2011;Croft et al., 2010).

Chronic musculoskeletal pain can persist for years rather than months (Rustøen et al., 2005). Evidence about longitudinal trends in musculoskeletal pain comes from population studies of people with pain assumed to be primarily musculoskeletal. A population study following 5093 community-based Americans aged ≥65 years (Thielke et al., 2012) found 33% of older people with pain experience symptoms lasting for three or more consecutive years, while another third experienced intermittent pain. In the UK, Jordan and colleagues (2012) found 31% of persons aged ≥50 years reported consistent pain symptoms at baseline, 3 and 6-year follow-up respectively; . of these participants whose pain status did not change, 19% reported pain that interfered with their daily lives and 12% reported pain that did not interfere with their lives (Jordan et al., 2012). Pain which consistently impacted upon daily life, (defined as pain which interfered 'moderately/quite a bit/extremely' with normal work, including both work outside the home and housework) was twice as common as non-interfering chronic pain. This and other evidence from similar population studies suggest musculoskeletal pain is an ongoing problem in older people. The proportion of older people experiencing significant, ongoing problems attributed to musculoskeletal pain however is likely to be even higher than these estimates, as many older people accept pain as an inevitable consequence of ageing (Cairncross et al., 2007), and so may not consult healthcare providers.

Musculoskeletal pain in older people can be difficult to manage despite the range of analgesic interventions and management strategies, even when the underlying disorder has been identified (Dieppe & Lohmander, 2005). A population based study of adults from 15 European countries and Israel found 40% reported inadequate management of their pain problem (Breivik et al., 2006). In a UK population-based study, approximately 48% of those aged ≥50 years who consulted primary care services with pain continued to have significant problems 6 months later (Mallen et al., 2013). Understanding and finding ways to lower the impact of persistent musculoskeletal pain upon older people remains an important public health issue.

2.3.4 IMPACT OF MUSCULOSKELETAL PAIN

Musculoskeletal pain impacts upon subsequent health and functional independence in older people (Regier & Parmelee., 2015; Kamaleri et al., 2009). A disability is a 'physical or mental impairment that has a substantial and long-term negative effect on [one's] ability to do normal daily activities' (HM Government, 2010a). A systematic review of causes of disease burden found musculoskeletal-related conditions were the second most common cause of global years lived with disability, with low back pain, neck pain, and knee osteoarthritis the three most common musculoskeletal conditions (Murray et al., 2012). Musculoskeletal dysfunction and pain can reduce an individual's capacity to perform daily activities (Richardson et al., 2014) and are associated with reduced mental and physical health (Dominick et al., 2012). Secondary physical and mental adaptations in response to musculoskeletal pain often become restrictive in their own right, e.g. increased stiffness and weakness of the musculoskeletal system arising from lack of use (Likivainio & Arokoski, 2008) and fear-avoidance behaviours (Cairncross et al., 2007).

Musculoskeletal disorders, of which pain is a primary symptom, are associated with an increase in the risk of other health conditions (McBeth et al., 2009; Dawson et al., 2005). An Australian population survey (Caughey et al., 2010) found arthritis the most prevalent type of health condition in older people (prevalence 54.2%), and four in every five respondents with arthritis reported one or more additional chronic conditions. Similar studies of UK-based populations have identified musculoskeletal disorders, cardiovascular disease, hypertension and mental health problems as four of the most prevalent chronic conditions in the older population (Islam et al., 2014;Craig & Mindell, 2005a;Craig et al., 2005b) and they often co-occur (Prados-Torres et al., 2014). Population based studies suggest having multiple conditions increases the risk of reporting poor self-rated health (Caughey et al., 2010), functional decline (Christensen et al., 2009) and hospitalisation (Wolff et al., 2002). Occurring in combination, health conditions are often more burdensome for both the individual and their primary care services than when occurring in isolation (Lawson et al., 2013;Heikkinen, 2003). This ultimately leads to an increase in health and social care costs (Palazzo et al., 2014; Dominick et al., 2012). Management strategies can be complicated as conditions may have conflicting or counter-indicated requirements for care. This makes managing individual conditions difficult, and the symptoms of one condition may exacerbate another (Chew-Graham et al., 2016;Tan et al., 2015;Valderas et al., 2009). It is widely agreed that reducing the onset of additional morbidities is a key health and wellbeing outcome in older people with musculoskeletal pain (AgeUK, 2014;ARUK, 2014). This thesis focuses on examining the role of social participation in determining which older people with musculoskeletal pain maintain mental and physical health and why.

2.4 MUSCULOSKELETAL PAIN AND MENTAL AND PHYSICAL HEALTH IN OLDER PEOPLE

2.4.1 MENTAL HEALTH

Mental health is a state of successful performance of mental function, resulting in productive activities, fulfilling relationships with other people, and an ability to adapt to change and to cope with adversity (DHHS, 1999), and is one of the outcomes examined in this thesis. Good mental health is defined as ‘the degree to which one feels positive and enthusiastic about oneself and life’ (Manderscheid et al., 2010). Mental illness is the term that refers collectively to all diagnosable mental disorders, characterized by alterations in thinking, mood, or behaviour and associated with distress and/or impaired functioning (WHO, 2001b;DHHS, 1999). In this thesis mental health has been operationalised as absence of depressive symptoms.

Depression is the most common mental health condition reported by older people, (WHO, 2016), with clinically significant depressive symptoms present in approximately 15% of community-dwelling older people (WHO, 2016;Blazer, 2003). Depression is associated with impaired functioning in daily life and accounts for 5.7% of years lived with disability in older people over 60 year olds (Blazer, 2003). It is associated with increased risk of morbidity, increased risk of suicide, decreased physical, cognitive and social functioning, and greater self-neglect, all of which are in turn associated with increased mortality (Blazer, 2003). Older women are twice as likely to report poor mental health than older men (WHO, 2012;Djernes, 2006), and depressive symptoms are more likely in those with a previous history of depression and those with a lack or loss of close social contacts (Djernes, 2006).

2.4.2 MUSCULOSKELETAL PAIN AND MENTAL HEALTH

Poor mental health is commonly reported by people with chronic musculoskeletal disorders (Dominick et al., 2012;Naylor et al., 2012;Dawson et al., 2005). Up to 33 per cent of women and more than 20 per cent of men with arthritis and other rheumatic conditions have co-morbid depression (Theis et al., 2007). Concurrent mental health problems and arthritis have been estimated to affect one in six older people (Caughey et al., 2010). A health survey of 5,808 randomly selected patients who attended a primary care clinic (Arnow et al., 2006) found respondents who reported chronic pain were three times more likely to report depression ($p<.001$), and disabling chronic pain was four times as likely in those with major depressive disorders. Equally, the number of people with mental health problems who report pain is particularly high, with 70% of people with anxiety and depression also suffering chronic pain (Smith et al., 2012).

Elderly people with clinically significant depressive symptoms are faced with a number of negative consequences including functional decline and disability (Richardson et al., 2014;Wilkie et al., 2013; Arnow et al., 2006), decreased quality of life, and higher mortality risk from comorbid medical conditions (Fiske et al., 2009). This 'loss' of previously enjoyable and fulfilling activities can negatively affect mood as well as diminishing self-esteem and self-efficacy (Cairncross et al., 2007). This can lead to further deterioration in mental and physical health, as well as having wider implications for an individual's social and economic status (Breivik et al., 2013). However, approximately one in three of those with persistent high intensity and/or widespread pain continue to maintain mental health, and this is most likely in those whose pain does not interfere with daily life (Jordan et al., 2012).

The precise nature of the relationship between musculoskeletal pain and mental health is complex and bi-directional (Tang et al., 2015;Parkinson et al., 2010). Many studies are cross-sectional, and do not address the important questions of whether musculoskeletal pain precedes or follows the development of mental health problems. Longitudinal studies suggest each condition increases the risk of the other (Arola et al., 2010;Gureje et al., 2001). For example, a study of older people found that troublesome pain at baseline was associated with approximately twice the risk of mental health problems 3 years later compared to those without troublesome pain (Arola et al., 2010). Conversely, a study of older women recruited at an out-patient pain clinic found baseline depression predicts both pain and pain related disability at subsequent time points (the study included 4 time points approximately 5-7 months apart) (Lerman et al., 2015).

2.4.3 PHYSICAL HEALTH

Physical health refers to the physical condition of the body's structure and function (Martini et al., 2011), and is the second outcome of interest in this thesis. There is no agreed, gold-standard definition of 'physical health' in the health or ageing literature (Sartorious, 2006). Good physical health was defined in this study as the physical capacity to adequately cope with all demands of daily life (Sartorious, 2006). Examples of demands of daily life include being able to mobilise independently and fulfilling tasks such as washing and dressing oneself. Poor physical health can arise from health conditions which manifest as physical illness (e.g. cardiovascular disease and cancer), or physical limitation (e.g. on walking) not attributed to a specific condition. Previous studies have captured physical health through self-rated health questions and/or the presence/absence of physical illness. For example, a systematic review by Rasmussen and colleagues (2009) defined physical health using a broad range of outcomes including; mortality, survival, cardiovascular outcomes, physiological markers (including immune function), immune function only, cancer outcomes, outcomes related to pregnancy, physical symptoms, and pain.

2.4.4 MUSCULOSKELETAL PAIN AND PHYSICAL HEALTH

Older people with musculoskeletal pain have increased risk of deteriorating physical health. The physical health outcomes affected by musculoskeletal pain are broad-ranging, and include global measures such as self-rated health (van Schoor et al., 2016;Perruccio et al., 2005), specific conditions such as cardiovascular disease (Parsons et al., 2014;Prados-Torres et al., 2014;Ryan et al., 2014), and functional impairment such as fatigue and difficulties with concentration and cognition (Breivik et al., 2006). Fatigue is reported by one in every two adults (aged 18+ years) reporting chronic pain, and difficulties with concentration and cognition reported by two in every five adults.

Specific diseases are linked with musculoskeletal conditions. A recent systematic review concluded musculoskeletal pain could influence lipid levels if persons with tendon injuries did less exercise and became inactive (Tilley et al., 2015). Persons with inflammatory arthritis such as rheumatoid arthritis have an increased risk of bacterial, tubercular, fungal, opportunistic, and viral infections (Doran et al., 2002). There is a growing body of evidence suggesting musculoskeletal pain is associated generally with subsequent reduced physical health in older populations (Tang et al., 2015;Wilkie et al., 2013;Blay et al., 2012).

2.4.5 MECHANISMS LINKING MUSCULOSKELETAL PAIN AND HEALTH

More than one mechanism drives the impact of musculoskeletal pain on health in any given individual (Rosenquist et al., 2015), dependent on the particular painful condition and the specific health outcome concerned. However more general mechanisms for the link between musculoskeletal pain and health can be classified into : 1) direct, 2) indirect, 3) shared and 4) reciprocal.

Direct mechanisms include the biological pathways of the hypothalamic-pituitary-adrenal (HPA) axis and the autonomic nervous system, which are activated in response to pain (Blay et al., 2012). The HPA axis controls reactions to stress and regulates the immune system and mood (Martini et al., 2011); the autonomic nervous system controls bodily functions not consciously directed, such as breathing, the heartbeat, and digestive processes (Martini et al., 2011). Through these pathways, the stress-response elicited by chronic musculoskeletal pain may stimulate maladaptive cognitive responses (e.g. magnification, rumination and helplessness) and predispose the individual to symptoms such as depression and pathological conditions such as peptic ulcers, insulin resistance and osteoporosis (Mazzantini et al., 2010;Whitworth et al., 2005).

Indirect mechanisms are exemplified by changes in physical activity. Persons with chronic musculoskeletal pain are less likely to be physically active (Holden et al., 2015;Munsterman et al., 2012), and lower physical activity is a risk factor for poor health outcomes (e.g. cardiovascular disease, diabetes and all-cause mortality) in older people (Soares-Miranda et al., 2016;de Rezende et al., 2014). An example of an indirect effect of pain on mental health is the reduction of an individual's capacity to fulfil their aspirations for lifestyle and employment because of a chronic painful musculoskeletal condition such as low back pain (Naylor et al., 2012;Dubé et al., 2005).

Shared pathways include immune and inflammatory mechanisms, which are one cause of musculoskeletal pain and also increase the risk of fractures, hypertension, myocardial infarction and serious infections (Mazzantini et al., 2010). Stiffness and musculoskeletal pain are symptoms of Parkinson's disease (Ozturk et al., 2016), and concurrent osteoarthritis and Parkinson's disease are associated with greater mobility impairment, which can then lead to increased pain (Ozturk et al., 2016). Inflammation is also associated with an increased risk of depressive symptoms and low mood (Miller & Raison, 2016; Zunszain et al., 2013). Increased levels of proinflammatory cytokines associated with inflammation can influence neurotransmitter metabolism, neuroendocrine function and regional brain activity, which are all factors associated with depressive symptoms (Zunszain et al., 2013).

Reciprocal relationships can occur between musculoskeletal pain and physical health as, for example, when osteoarthritis pain arises from pathological changes in the joints and muscles, leading to reduced mobility and muscle strength, which in turn cause further pathological deterioration in joints (Hunter & Eckstein, 2009). There is a reciprocal cycle between musculoskeletal pain and depression, with mood, emotions and interactions with others posited to influence subsequent pain appraisal. Depression has been linked to negative changes in affective and cognitive processing (Fiske et al., 2009) which reduce motivation to adhere to pain-management strategies and alter interpretation of physical sensations (Turk & Okifuji, 2002).

2.5 SOCIAL PARTICIPATION IN OLDER PEOPLE

2.5.1 WHAT IS SOCIAL PARTICIPATION?

There is still no formal consensus on a single definition of social participation or the underlying dimensions (Wilkie et al., 2011;Magasi & Post, 2010;Levasseur et al., 2010; Hammel et al., 2008;Ekstrom et al., 2008). 'Participation' activities are defined by the International Classification of Functioning, Disability and Health (ICF) as those constituting 'involvement in a life situation' (WHO, 2001). However, this definition has been criticised for lacking clarity over what constitutes a 'life situation' (Whiteneck & Dijkers, 2009), and for being difficult to operationalise as a measure (Dijkers, 2010;Hammel et al., 2008). 'Social participation' is a more specific term, which the ICF (WHO, 2001) describes as actions and tasks required to engage in organized social life outside the family, in the community, and in social and civic areas of life. While this definition is more specific than that of 'participation', it still lacks clarity over how social participation activities can be differentiated from other functional activities. This is especially a problem if it is not possible to obtain details of the purpose of actions and tasks performed by an individual. For example, empirical research often uses data collected via questionnaires or surveys, so does not provide the researcher with the ability to probe responses for details of the purpose or end goal of functional activities. Clarity over what is meant by social participation is further diminished by the fact that multiple terms are used to refer to the concept of social participation, while additionally the label 'social participation' is used to refer to alternative concepts.

For the purpose of this thesis, the definition of social participation was taken from a systematic review of health and gerontology literature published between January 1980 and February 2009 and performed by Levasseur and colleagues (2010). This sought to identify and synthesise original definitions of social participation. The review identified a working theoretical model of social participation and the underlying dimensions from the review findings. This definition was selected as it was developed from the most recent systematic review of social participation definitions identified at the start of the PhD research. The definition acknowledges and is informed by 43 original definitions identified by Levasseur et al (2010) through a comprehensive search strategy, which included 'community involvement', 'community participation' 'social engagement' and 'social involvement' in addition to 'social participation'. Of the 43 original definitions identified, 31 were found in articles published between 2000 and 2009, indicating the recent swell in interest in social participation. Using content analysis, the dimensions of activities contributing to the definitions were examined and findings synthesised to develop a social activities taxonomy which could be used to distinguish activities which constituted social participation (Levasseur, et al., 2010). The social activity taxonomy spanned a continuum of six levels, ranging from 1) preparing for social interactions, to 6) contributing to one's community (Figure 2:2).

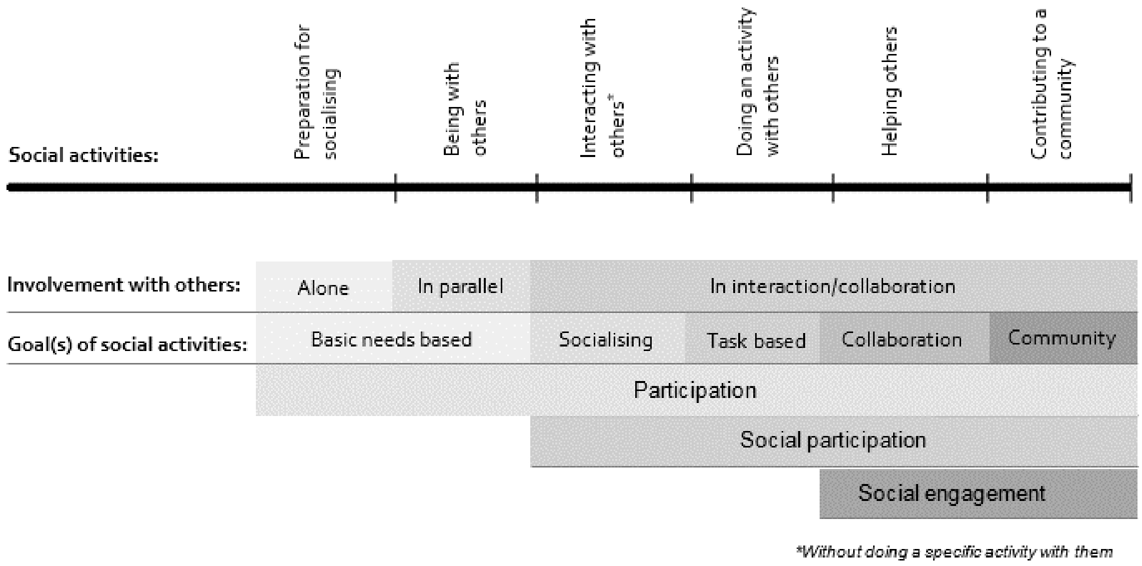


Figure 2:2 The concepts of participation, social participation and social engagement. Source: original, based upon the social activities model adapted from findings of Lavasseur et al., 2010

In the model developed from their findings, Levasseur and colleagues qualify the type of participation occurring in social participation as being contingent on social interactions (Levasseur, et al., 2010). They distinguish between participation, social participation and social engagement on a continuum of activities. This operationalisation captures functioning at a societal level and, unlike the broader definition proposed in the ICF, provides a more easily applied criterion for differentiating whether an activity constitutes social participation. The definition also places more emphasis on the social component of social participation, addressing the concerns of critics who argue that the difference between social participation and participation are unclear (e.g. Whiteneck & Dijkers, 2009). This is primarily done in terms of differences in the goal(s) of activities, and the level of involvement with others.

Goals ranged from basic needs (e.g. nourishment or shelter), through task-based and collaborative ends, to community-level goals (e.g. productive activities or those which benefit other persons). As defined in the ICF, participation is an umbrella term, including all basic and complex activities whatever the goal and whether performed alone or in collaboration (Levasseur, et al., 2010). Social participation is defined as activities ranging from those performed in parallel (i.e. surrounded by others) to helping or collaborating with others (e.g. working towards shared goals or being a member of a committee). Social engagement includes non-obligatory activities which require active and meaningful engagement, and involve 'a desire for social change or to be heard to affect community choices' (Levasseur et al., 2010). Participation thus incorporates both social participation and social engagement, and social participation encompasses social engagement. While goals and level of involvement with others were considered independently in the model, the two aspects of activities are often linked.

Lavasseur et al., (2010) do not stipulate that social activities constituting social participation should be performed face-to-face, but rather suggest they should occur in the same social environment, which includes virtual environments such as internet chat-rooms and video-conferencing. Online social interactions are increasingly being recognised as an important source of social participation (Hartnett, et al., 2013). Another environmental caveat sometimes applied to definitions of social participation is a necessity for social participation to be performed outside the home environment (Goll, et al., 2015). However, Lavasseur et al., (2010) do not make this an explicit condition in their model. Similarly, they do not place emphasis on the flow or direction of resources during the social activities, which some others have suggested as an integral aspect of social participation (Maier & Klumb, 2005;Bukov et al., 2002). For example, Mars et al., (2008) identify social contact and the contribution or receipt of resources to one's community as fundamental dimensions of social participation. However, in the Levasseur model of social participation, the flow of resources is not considered pertinent to social engagement activities.

Driven by a synthesis of definitions of social participation identified in a systematic search of the literature, the model of Levasseur and colleagues (2010) presents a definition which reflects those commonly applied in the literature. It sits midway upon a spectrum of definitions found in the health and gerontology literature. On one side there are studies (e.g. Wilkie et al., 2007) which include any interaction between an individual and their environment (e.g. including personal care and managing finances). On the other side are studies explicitly defining social participation as involvement only in social and civic affairs occurring outside the immediate home and work settings (e.g. Baum et al., 2000). Such consumer involvement may also be referred to as 'social', 'public' or 'civic' engagement (NCCPE, 2016;Piškur et al., 2014).

Contrary to concepts such as social networks (i.e. an objective measure of social relationships) and loneliness, social participation is not concerned with quantifying objective or subjective characteristics of an individual's social environment, but relates instead to how, why and with whom an individual interacts within their environment (Levasseur et al., 2010). For example, two similar people may have equal sized social networks but one may participate in more social activities than the other, so social network is not a synonym for social participation. Loneliness and social embeddedness capture perceived quantity or quality of social relationships (Hawkley, 2015), and social support captures perceived access to resources (Berkman et al., 2000). The end goal of interacting with others is an important characteristic of social participation (Mars et al., 2008), and is not captured by concepts such as social network size or perceived loneliness. Whilst these factors may be important outcomes or prognostic factors in older people, they are distinctive from social participation. A review by Dickens and colleagues (2011) found that participatory interventions were almost twice as likely to provide beneficial effects on mental and physical health as non-participatory interventions in community-dwelling older people (around 80% had significantly better outcome compared to 44%). However, high levels of bias risk were identified for many of the included studies during quality assessment. Social participation is consequently an important interventional target, and a marker of social functioning and engagement within one's social environment in older people, and is compatible with models of successful ageing (Binstock & George, 2011).

2.5.2 FACTORS INFLUENCING SOCIAL PARTICIPATION IN OLDER PEOPLE

As people age, social participation changes because of life-cycle transitions (e.g., becoming a grandparent, retirement), and declining individual capacities (e.g. mental and physical health). Social participation frequency is lowest in the oldest old, and this is usually associated with increasing functional limitation and ill health (Croezen et al., 2009;Wilkie et al., 2006;Bukov et al., 2002). Older age is associated with a reduction in productive (i.e. contribution of services, goods and benefits to others) and politically-orientated social participation activities (Croezen et al., 2009;Bukov et al., 2002), and increased difficulty maintaining social interactions (Wilkie et al., 2006; Desrosiers et al., 2004). This reduction is linked to age-associated restrictions in the physical and psychological capabilities needed to fulfil social roles and engage in social activities (Charles & Carstensen, 2010;Wilkie et al., 2007). In earlier old age, the overall levels of social participation can often be maintained through adaptation and substitution of social participation activities if and when specific social roles or activities become too difficult to maintain (Bukov et al., 2002). For example, being a football player is physically demanding and may become difficult due to hip or knee osteoarthritis, but could be replaced by a team coaching role.

Low income and female gender are also associated with less or restricted social participation in older people (Wilkie et al., 2007; Bukov et al., 2002). A British population survey of people aged 65 or more (n=761) found those living in less affluent areas have lower levels of social participation than those in affluent areas, independent of individual demographic and socio-economic characteristics (Bowling & Stafford, 2007). Older men are more likely to be engaged in productive activities and in political activities and clubs, whereas older women are more often care-givers or volunteers for groups or organisations (Luo et al., 2012; Stelle et al., 2010; Bukov et al., 2002). This difference between men and women may be influenced by gendered social norms, and differences in opportunities or personal characteristics.

Environmental factors will facilitate or inhibit social participation. Availability of education and employment affects social participation (Bowling & Stafford, 2007) in older people. Ease of access of facilities (e.g. community gardens, urban locations and accessible social spaces), mobility links (e.g. drivers licence or public transport links) and availability of other people (e.g. neighbourhood density) are associated with maintaining social participation, as is social support from others (Levasseur et la., 2015).

Personal characteristics and beliefs contribute to an individual's social participation (Goll et al., 2015). One example is social identity (Lund & Engelsrud, 2008), with older people seeking continuity of aspects of their self-identity across their life-course through their pursuit of social participation activities. Factors arising earlier in the life course (e.g. occupational roles, religious orientation and engagement with social groups whilst raising children etc), contribute to the social participation activities an older person finds most salient to their personal identity. Another example is sociability (Charles & Carstensen, 2010), and when difficulties maintaining social participation arise, older people may respond by ceasing the activity because of fears of social rejection and/or exploitation, or lack of sufficient social support to maintain them (Goll et al., 2015). However, the need for social interaction and interpersonal attachments persists across the life course (Nicolaisen & Thorsen, 2016; Baumeister & Leary, 1995).

2.5.3 SOCIAL PARTICIPATION AS AN IMPORTANT DETERMINANT OF HEALTH IN OLDER POPULATIONS

Social participation is widely recognised as an important determinant of health in older populations (Benka et al., 2016;Chiao et al., 2011;Holt-Lunstad et al., 2010;Levasseur et al., 2010;Reblin & Uchino, 2008). Social participation captures the interaction of an individual with their social and structural environment. This interaction can affect health, and is a two-way process. For example, evidence suggests health and wellbeing predicts social participation (Ekstrom et al., 2008; Wilkie et al., 2007), and social participation predicts health system usage and health outcomes (Benka et al., 2016; Chiao et al., 2011; Holmes & Joseph, 2011; Glass et al., 1999). These loops are captured by the model shown in Figure 2.3, which is adapted from the Conceptual Framework for Action on the Social Determinants of Health (CSDH) by adding social participation.

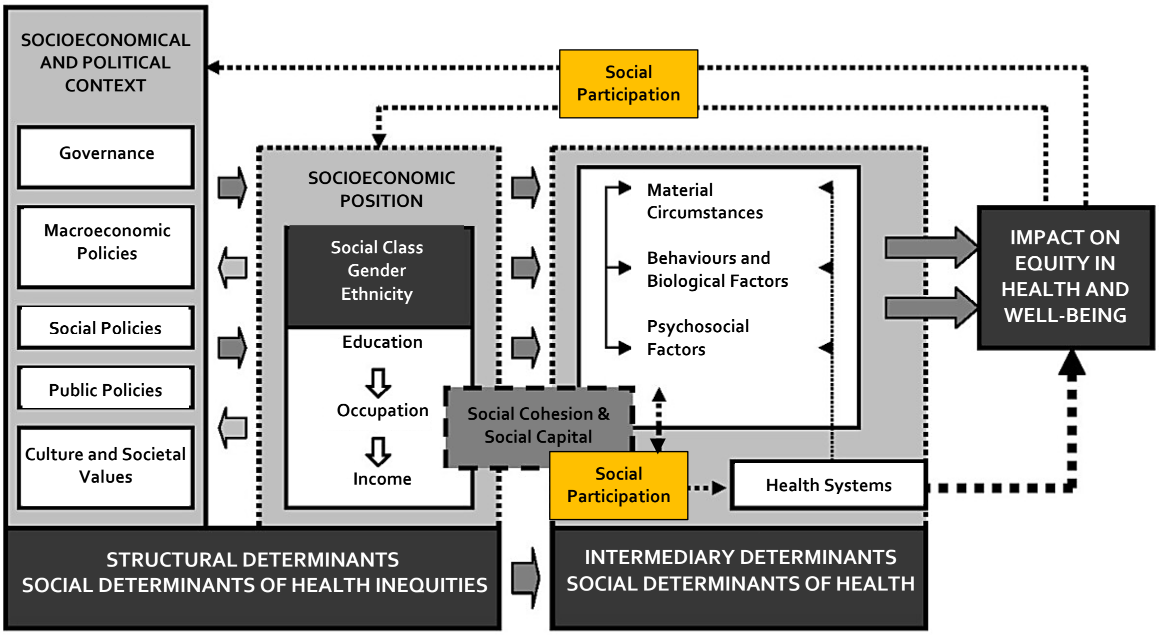


Figure 2:3 An adapted Commission on Social Determinants of Health (CSDH) conceptual framework, with the contribution of social participation added. Source WHO, 2010

The CDSH incorporates the role of existing illness and health care provision, as well as considering contextual factors at both a community (e.g. policies, social norms) and individual level (e.g. socioeconomic position and gender). The CSDH framework describes how social factors determine the association between musculoskeletal pain and subsequent health, in conjunction with socio-structural conditions (labelled as ‘socioeconomic and political context’), health systems, and modifiable aspects of material circumstances, psychological, behavioural and biological factors (i.e. individual level factors). The framework includes reciprocal and bi-directional relationships which better represent the reciprocal relationship found between social participation and existing health at an individual level, and incorporates both objective and subjective measures of social factors. For example, social cohesion and social capital are included in the model, and link socioeconomic factors to factors representative of an individual’s biologic and personally derived abilities (as described in the Meikirch model of health). By considering how social participation activities may fit within the components of the CSDH framework, and how the flow of social resources influence health, underlying rationales can be developed for the potential roles of social participation in determining which older people with musculoskeletal pain maintain their health or not.

2.5.4 HEALTH BENEFITS OF SOCIAL PARTICIPATION IN OLDER PEOPLE

Downstream benefits of social participation may explain how social participation influences mental and/or physical health in older people with musculoskeletal pain. The categorisation of these benefits (social support, sense of purpose, physical activity) was developed by SB as a framework to present and discuss the effects of social participation in the studies making up this thesis, and each category is summarised briefly below. This was done using the systematic review described in a later chapter, and by drawing on a separate study undertaken by SB with a focus group and not included in the thesis (but summarised for information in Appendix 3).

SOCIAL SUPPORT

Social support can be depicted in terms of four subtypes; emotional, instrumental, appraisal and informational (Binstock & George, 2011). The type of social support sought or drawn upon is dependent on the situation. Social support is both a resource accessed through social participation (Drennan et al., 2008;Berkman et al., 2000) and a determinant of subsequent social participation (Levasseur et al., 2015). Greater perceived social support is associated with increased psychological and physical health in adults (Bowen et al., 2014; Holt-Lunstad et al., 2010; Cohen, 2004), lower risk of depressive symptoms (Wicke et al., 2014), and better self-rated health (White et al., 2009). Social support has also been shown to predict increased positive mental affect and reduced depressive symptoms in older people with musculoskeletal pain (Lee et al., 2015;Mavandadi et al., 2007). It has been suggested that perceived social support may influence how individuals appraise the impact of existing morbidity on their health-related quality of life, with a lack of support associated with increased risk of depressive mood, while the perception of good social support may attenuate a threat to health, and so promote mental and physical health in older people (Wicke et al., 2014). There is also evidence that providing social support to others is associated with better health (Piferi & Lawler, 2006). Furthermore, those who report giving more support also report getting more support (Piferi & Lawler, 2006).

Giving and receiving support increases self-efficacy, leading indirectly to lower stress, while receiving support has a direct effect attenuating stress (Piferi & Lawler, 2006). Discussing health problems with members of one's social network has been linked to better cardiovascular health outcomes (Cornwell & Waite, 2012), and social support has been suggested to eliminate or reduce effects of stressful experiences by promoting less threatening interpretations of adverse events and effective coping strategies (Cohen, 2004). Advice and appraisal from peers on health matters has been suggested to shape behaviours and promote sharing of health information and knowledge (Uchino, 2006), and provides psychological resources for dealing with problems and adversities such as musculoskeletal pain (Andrews et al., 2014). Aspects of social support (e.g. the information and advice received through social participation) can also modify behaviours which are associated with health (e.g. eating, drinking and smoking habits) (Berkman et al., 2000). The opinions and influence of others can prompt one to consider aspects of one's health previously not considered, challenge their point of view and change how they interpret their health (Richardson et al., 2014;Grime et al., 2010). Attitudes are 'confirmed and reinforced' when an individual interacts with others who share their beliefs, and 'reappraised and altered' when they are discrepant (Marsden & Friedkin, 1994;p.5). Social interactions may provide information and exposure to beneficial healthy behaviours, acting as a source of motivation and social pressure to care for oneself (Cohen, 2004).

SENSE OF PURPOSE

A sense of purpose describes the actualisation of self-development, personal growth and purposeful engagement which give meaning to an individual's existence (Ryff et al., 2004). Having a sense of purpose is one component of wider mental wellbeing, which describes one's capacity to realise his/her own abilities, cope with the normal stresses of life, form positive relationships with others, feel connected and supported and contribute productively to their community (WHO, 2001). Social participation can provide a sense of purpose in life through involvement in meaningful activities (Cosco et al., 2014;Charmaz, 1983), for example by helping to care for grandchildren or by fulfilling a voluntary role within one's local community. Participating in social activities provides an opportunity to exert choice and autonomy, contributing to a sense of purpose and helping individuals to remain optimistic about the future, mitigating the negative impact of musculoskeletal pain and/or disability upon daily life (Ferreira & Sherman, 2007).

Engagement in social participation can also enable participants to continue aspects of earlier stages of their life-course that were meaningful to them, helping to maintain important aspects of social identity and providing a sense of continuity into later life (Nicolaisen & Thorsen, 2016). A small study of 59 older people under-going knee replacement surgery also found that purpose in life was directly related to better mental health and indirectly related, through active coping, to better physical health (Smith & Zautra, 2000). The results remained significant following adjustment for initial health and age, education, and gender. Maintaining a sense of purpose can help to buffer the negative impact of musculoskeletal pain and associated disability by reducing stress, improved coping, and supporting individuals to make healthy lifestyle choices (Hooker et al., 2017).

PHYSICAL ACTIVITY

The positive relationship between physical activity and health in older people is well documented (Mura & Carta, 2013;Munsterman et al., 2012; Asztalos et al., 2010). Physical activity is associated with more years of active independent living, reduced disability and improved quality of life for older people (Sun et al., 2013). A large scale longitudinal study found that every additional 15 minutes of daily physical activity, up to 100 minutes per day, resulted in a further 4% decrease in mortality from any cause (Wen et al., 2011). Social participation includes physically active social activities such as bowls and dancing, so constitutes a source of physical activity in older people. Social participation is well placed to promote physical activity in a stimulating environment, as part of meaningful engagement with other members of one's social network. Performing activities with or supported by others is associated with greater chance of sustaining physical activity in older people (Holden et al., 2015;Park et al., 2014). Park and colleagues (2014), in their study of motivational and social cognitive strategies related to physical activity, reported that participants did not seem to consider physical activity as the first priority in their everyday lives. This was echoed in the findings of the focus group study (Appendix 3), which found participants rarely prioritised physical activity when planning their days. Personal preference and motivations play an important role in determining how musculoskeletal pain and disability influenced the social participation activities of individuals, and how they responded to musculoskeletal pain.

Social participation offers additional benefits to those associated with physical exercise performed alone. For example, empirical studies have used factor analysis to test factors underlying adult leisure activities, and have found social activities to be distinctive from physical activities (Jopp & Hertzog, 2010) and solitary active or sedentary activities (Lennartsson & Silverstein, 2001). In their mixed-method study Holden and colleagues (2015) interviewed a subsample of 22 participants with knee pain to explore their experience of exercising. They found that physical activity with others was preferred as it constituted an enjoyable social experience, provided motivation to continue to exercise and to work harder during the exercise session, and helped individuals to cope better with their knee problem.

2.5.5 SOCIAL PARTICIPATION AS A DETERMINANT OF HEALTH IN OLDER PEOPLE WITH MUSCULOSKELETAL PAIN

This chapter has examined evidence of relationships between social participation, musculoskeletal pain and health, and presented a framework to describe, categorise and analyse how social participation may influence the association between musculoskeletal pan and health. The framework is summarised in Figure 2.4. The framework highlights that musculoskeletal pain may influence usual social participation activities (e.g. work and family roles and leisure time activities), and this is influenced by personal and environmental factors. Continuing social participation activities, despite musculoskeletal pain, may benefit health by promoting beneficial health behaviours, providing a sense of purpose and access to social support and/or by providing a source of physical activity.

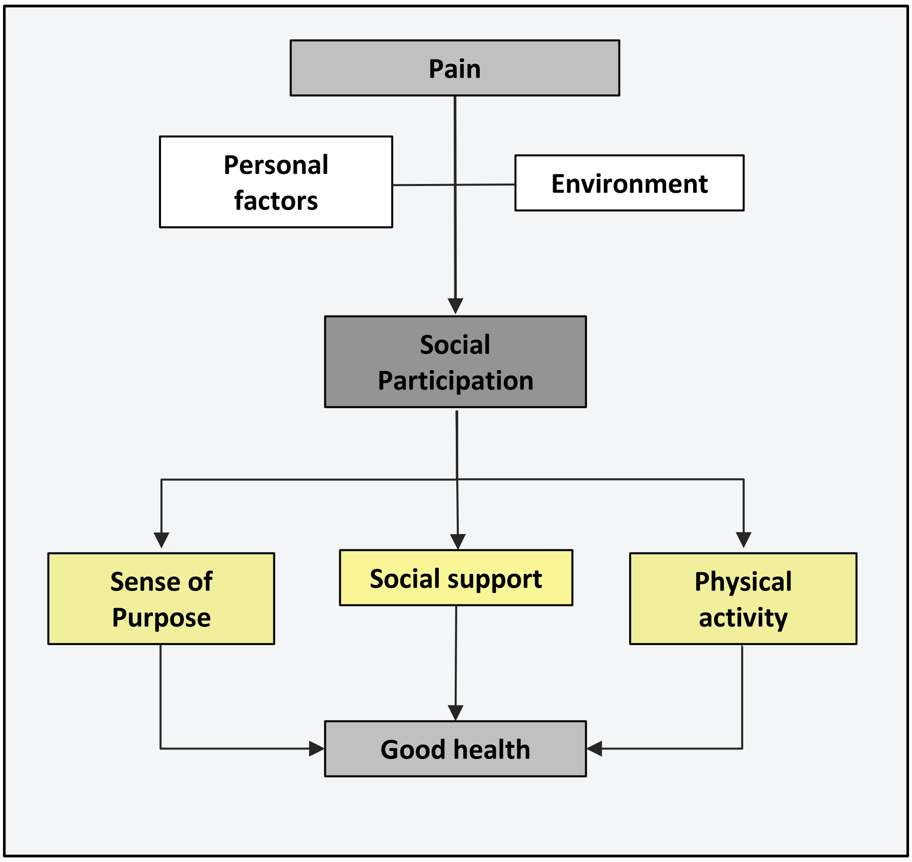


Figure 2:4 Proposed framework for describing, categorising and analysing the role of social participation in determining which older people with musculoskeletal pain maintain good health. Source: Original

While frameworks, such as Figure 2:4, provide useful tools to summarise evidence, consider how multiple factors can contribute towards health and generate a research hypothesis, empirical analyses are required to test such hypotheses. To examine whether and how social participation influences the association between pain and mental and physical health, the next step was to develop statistical models for carrying out the empirical tests. In these statistical models social participation is referred to as a 'third variable'. Concepts underlying each of these three 'third variable' hypotheses (effect mediation and moderation, and confounding) and their rationale and analysis will be described in the next chapter.

2.6 CHAPTER SUMMARY

Promoting health in older people with musculoskeletal pain is an important public health agenda. Whilst it is known that social participation is associated with health in older people it is not known what specific role(s) social participation plays in determining which older people with pain maintain their mental/physical health. There are three distinctive third variable roles social participation may fulfil: effect mediator, effect modifier and confounding variable. Currently there is a lack of empirical research that tests whether social participation fulfils any of these roles in explaining the maintenance of mental and physical health. The thesis aims to address this important gap in the health literature.

CHAPTER THREE: ANALYSIS OF SOCIAL PARTICIPATION AS A 'THIRD FACTOR'

3.1 CHAPTER OVERVIEW AND INTRODUCTION

This chapter provides a background to 'third factor' analyses - effect mediation, effect moderation and confounding - and describes how these are empirically tested. As a determinant of the association between musculoskeletal pain and good mental/physical health, social participation must fulfil a third variable role. A third variable is an additional variable which influences the observed association between the two primary variables (i.e. the exposure (e.g. musculoskeletal pain) and outcome (e.g. mental health)). There are three roles a third variable could fulfil: effect mediator, effect modifier, confounding variable. Alternatively, a postulated third variable may turn out to have no effect. While the possible third variable roles are conceptually distinctive, a given variable may fulfil more than one role with regards to a specific exposure-outcome relationship (Szklo & Nieto, 2014). No single, definitive statistical method exists by which to determine which role(s) social participation fulfils in the association between pain and mental/physical health (Magill, 2011; MacKinnon et al., 2002). The following sections use 'Directed Acyclic Graphs' (DAGs), to describe the conceptual underpinnings of each of the third variable roles. In causal DAGs an arrow indicates the presence and direction of causal relationships between two variables, and variables with no direct causal association are left unconnected. DAG theory is explained in more detail in Appendix 1.

3.2 SOCIAL PARTICIPATION AS AN EFFECT MEDIATOR

3.2.1 DEFINING AN EFFECT MEDIATOR

Effect mediation occurs when the association between an exposure and an outcome is explained all, or in part, by a third, intermediary variable (MacKinnon, et al., 2014). Conceptually, this translates to social participation featuring on the causal pathway between musculoskeletal pain and health, explaining some (partial mediation), or all (total mediation), of the observed effect of musculoskeletal pain on health (MacKinnon et al., 2014). Mediation pathways are driven by a sequence whereby a change in the exposure leads to change in the mediator, which in turn causes change in the dependent variable. The three 'paths' of interest to those examining effect mediation are:

- the total effect (the observed association between the exposure and outcome) (MacKinnon et al., 2014). This is known as the C path;
- the direct effect (the part of the total effect which is directly due to a change in the exposure causing a change in the outcome) (MacKinnon et al., 2014). This is known as the C' (c dash) path;
- the indirect effect (the part of the total effect which is explained by change in the exposure causing a change in a third variable, which then causes a change in the outcome) (MacKinnon et al., 2014). This is shown by the a and b paths.

Figure 3:1 provides the underlying theoretical model for social participation as an effect mediator of the relationship between musculoskeletal pain and health.

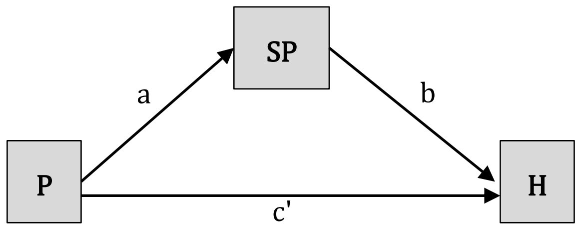


Figure 3:1 A directed acyclic graph illustrating social participation (SP) as an effect mediator of the relationship between musculoskeletal pain (P) and health (H). Source: Original

The total effect is the effect observed between an exposure and an outcome. To test for effect mediation, the total effect is decomposed into the effect on the outcome directly caused by the exposure (direct effect), and that which occurs indirectly as a result of the exposure influencing the mediating variable, which then influences the outcome. Conceptually this means that musculoskeletal pain should be causally associated with health, with some or all of this causal effect explained by the effect of musculoskeletal pain on social participation, and the subsequent effect of social participation on health.

3.2.2 RATIONALE SUPPORTING THE ROLE OF EFFECT MEDIATOR

To support the hypothesis that social participation mediates the pathway between musculoskeletal pain and maintaining good health, it is necessary to provide a convincing argument for social participation being on the causal pathway between musculoskeletal pain and health. Musculoskeletal pain is a known predictor of restricted social participation in older people (Wilkie et al., 2013), and longitudinal studies have found maintaining social participation is associated with maintaining health (Cornwell & Waite, 2012;Barth et al., 2010;Forsman et al., 2011). Therefore, it is possible that continuing to fulfil social roles and engage in social activities, despite being troubled with musculoskeletal pain, may help delay or prevent the deterioration in mental and physical health (Gardner, 2014).

Effect mediation sets out to test whether a change in the exposure causes a change in the mediating variable, which in turn causes a change in the outcome (Hayes, 2013). However, in this thesis the hypothesis is that social participation acts as a buffer to attenuate the effect of musculoskeletal pain upon subsequent health. Therefore frequent social participation is hypothesised to reduce the risk of a deterioration in health usually associated with musculoskeletal pain. Drawing upon the model in Section 2.5.3.3, one hypothetical pathway by which social participation may be an effect mediator of the relationship between musculoskeletal pain and mental/physical health could be:

1. pain threatens to restrict an older person's social participation;
2. by maintaining social participation, older people access benefits such as social support and social influence, to encourage healthy behaviours and self-management capabilities and physical fitness;
3. the benefits accessed through social participation help the older person to maintain their mental/physical health.

This hypothetical pathway is valid for both mental and physical health outcomes, but it is possible that nuanced differences are found between the mechanisms determining mental/physical health specifically. Social participation may explain the association between musculoskeletal pain and subsequent mental health by providing individuals with a 'sense of coherence' through participation in meaningful activities with others and affirmation of aspects of their social identity (Lund & Engelsrud, 2008). These may be threatened if musculoskeletal pain limits aspects of daily life (Bailly et al., 2015). Social participation may also improve mood and reduce depressive symptoms (Chiao et al., 2011; Forsman et al., 2011), thus protecting mental health. Additionally, it may be that behavioural and physiological pathways facilitated by social participation (Berkman et al., 2000) help to maintain health in older people with musculoskeletal pain. For example, social interactions arising from social participation may influence individuals to follow healthy behaviours (Adam et al., 2000) or reduce stress. This could reduce the risk of physical health outcomes such as high blood pressure, cardiovascular disease (Cornwell & Waite, 2012;Barth et al., 2010) and poor self-rated health (Hillen et al., 2000).

3.2.3 EMPIRICALLY TESTING FOR EFFECT MEDIATION

At least 14 different methods of estimating effect mediation exist, falling into three broad approaches: causal steps, differences in coefficients and product of coefficients (MacKinnon, et al., 2002). While the aim of each method is to decompose an observed effect between two variables into a direct and indirect effect, each has its own respective strengths and limitations. In this thesis, the product of coefficients approach was used. This method tests whether the direct effect of path c' is significantly smaller than the total effect (indicated by a significant indirect effect). The product of coefficients method was selected as it is more easily generalised to complicated mediation models, i.e. models with covariates or multiple mediators, than the difference in coefficients approach, and has greater statistical power than the causal steps method (MacKinnon, et al., 2002). The causal step method can also be performed using multivariable logistic regression, which is required to accommodate binary mediators (in this thesis both the mediator variable and the outcome variables were binary). The distribution of the outcome in a multivariable logistic regression model is assumed to follow a logit distribution, and can be expressed using Equation 1:

$$Ln\left[\frac{Y}{(1-Y)}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_n X_n \qquad (Eq.1)$$

Y is the occurrence (coded 1) or not (coded 0) of the mental/physical health outcome that is being modelled, the unknown parameters are denoted by βn, which represent a scalar or a vector coefficient for independent variables (e.g. pain, age and gender), and the independent variables are given as Xn (Spicer, 2005). Ln indicates the natural log. First the observed total effect (C path) is calculated. Then the extent of the total effect attributable to effect mediation is examined by decomposing the total effect into a direct effect (C' path) and an indirect effect through the a and b pathways. The product of the coefficients for pathways a and b are then calculated to examine the indirect effect.

Odds ratios (ORs) are then calculated by exponentiating the coefficients. An OR is the odds of exposure in the group with the outcome of interest divided by the odds of exposure in those without the outcome of interest (Spicer, 2005). In this thesis, the direct effect was interpreted as the odds of reporting good mental/physical health when pain was reported at baseline which was not explained by social participation. The variables were coded to provide intuitively interpretable coefficients for pain and social participation in predicting good mental/physical health, i.e. the coefficients yielded related to the ORs associated with the predictor (e.g. pain or frequent social participation) being present. This enabled the OR of good mental/physical health associated with reporting musculoskeletal pain or social participation to be identified. However, this also meant the resulting natural direct effect was not intuitively interpretable. The natural direct effect is the effect which would naturally occur under the reference condition for the exposure and mediator (VanderWeele & Vansteelandt, 2010). The conditional natural direct effect odds ratio can be defined analogously, and takes the form:

$$OR^{NDE}_{a,a*|c}\,(a*) = \frac{P\left(Y_{aM_{a*}} = 1\middle|c\right)/\{1\text{-P}\left(Y_{aM_{a*}} = 1\middle|c\right)\}}{P\left(Y_{aM_{a*}} = 1\middle|c\right)/\{1\text{-P}\left(Y_{a*M_{a*}} = 1\middle|c\right)\}} \qquad Eq\ 8.1$$

In the case of this thesis the referent value of pain was 'no pain', and the referent value of social participation 'infrequent', as this allowed the coefficients to represent the change in odds associated with the presence of pain or frequent social participation respectively to be examined. However, this meant the conditional natural direct effect of social participation compared infrequent socialisers without pain to frequent socialisers without pain. Therefore, when examining any effect mediation, the changes in magnitude and statistical significance of the indirect effect were the main information of interest. Further details of the theory underpinning the product of coefficients approach are provided in Appendix 4.

This thesis also used multiple parallel mediator models to examine the extent to which any mediating effect of social participation was explained by the identified downstream health benefits (i.e. physical activity, social support and a sense of purpose). A mediation model with multiple, parallel mediators allows the direct effect to be examined whilst accounting for the combined effects of all proposed mediators, and can control for both collinearity among variables and mediation effects. This means any significant mediation effects are unique (Hayes, 2013). Parallel mediation assumes that all constructs mediate the relationship between exposure and outcome in a comparable manner (Jones et al., 2015a). This enabled the relationship between pain and social participation to be examined once associations between pain and the identified factors accessed through social participation (i.e. social support, physical activity and a sense of purpose respectively) were accounted for. In multiple mediation models the direct effect is further adjusted for the additional mediators.

Three important threats to internal validity and bias when testing for effect mediation were considered, and attempts made to mitigate the effect in this thesis. Firstly, measurement bias of the exposure, outcome and effect mediator can result in biased estimates of the mediating effect. Most frequently the total effect is attenuated, while measurement error of the mediating variable can result in an overestimate of the mediating effect (Baron & Kenny, 1986). In this thesis, the use of bootstrap confidence intervals was used to address this limitation (VanderWeele, et al., 2012).

A second important consideration when estimating effect mediation is feedback or reciprocal effect patterns (Marsh, et al., 2006). Feedback occurs when there is a reciprocal pattern of association between the exposure and the outcome of interest, for example depression is associated with subsequent pain severity, and pain severity associated with subsequent chance of depressive symptoms (Chou, 2007). For this reason, it is recommended that cross-sectional mediation models are not used to test for mediation effects (Roe, 2012), as the direction of effect between two variables cannot be definitively established. Consequently, the temporal sequence of measurements of the exposure, outcome and effect mediator constitute a fundamental aspect of the theory underpinning effect mediation in observational studies; a change in the exposure must precede a change in the effect mediator, and a change in the effect mediator precede a change in the outcome to suggest a causal pathway. Strategies to address reciprocal effect mediation were incorporated into this thesis. As recommended by Maric and colleagues (2012), the study design incorporates more than two assessment points, and measures of social participation (the mediator) and mental/physical health from multiple time points were used to explore the reciprocity of mediating effects to be tested as part of a sensitivity analyses.

Collinearity between the exposure and effect mediator can be a threat to internal validity when testing for effect mediation. Collinearity occurs when one variable in a regression is highly correlated with a second variable. If social participation is a successful mediator, then collinearity between musculoskeletal pain and social participation is inevitable, and expected, because a change in social participation follows a change in musculoskeletal pain. High collinearity reduces the precision of the regression estimates. Using a conceptual theory approach to developing statistical models for testing effect mediation, as done in this thesis, is recommended as one method by which to mitigate the impact of collinearity between the exposure and effect mediator on the precision of effect mediation estimates (Beasley, 2014). Ensuring a mediator is strongly related to the outcome increases the value of the b path, increasing the statistical power to detect effect mediation (Beasley, 2014). However, excessive multicollinearity can lead to coefficient estimates which are unstable and depletes the statistical power of the analysis (Menard, 2002). Variance inflation factors were also used to examine multicollinearity between the exposure and effect mediating variables in this thesis.

3.3 SOCIAL PARTICIPATION AS AN EFFECT MODIFIER

3.3.1 DEFINING AN EFFECT MODIFIER

Effect modification (sometimes referred to as 'moderation') arises when the effect of an exposure on an outcome differs according to the value of a third, effect modifying, variable. Effect modification describes the situation whereby 'two or more risk factors modify the effect of each other with regard to the occurrence or level of a given outcome' (Szklo & Nieto, 2014). An effect modifier may diminish or accentuate an effect, or it may be that at certain values of the effect modifier there is no association observed. Effect modification does not necessarily indicate causality, but rather identifies a natural difference in the level of association between an exposure and outcome (Hayes, 2013) Effect modification studies therefore are used to answer questions about when (i.e. under what conditions) or for whom (i.e. which groups/types of cases) an exposure has a stronger/weaker association with an outcome. Epidemiologists often use the term 'interaction' interchangeably with effect modification (Szklo & Nieto, 2014; Marsh, et al., 2013), but conceptual distinctions and differences in underlying statistical theory exist between the two terms (VanderWeele, 2009; Kaufman, 2009). Statistical interaction refers to a property of the data, and may be interpreted as empirical evidence of effect modification. Importantly, the two terms are not synonyms as effect modification may be present in the absence of a significant statistical interaction. In this thesis 'effect modification' is used to refer to the situation whereby the association between an exposure and an outcome differs according to the level or occurrence of a third variable (Szklo & Nieto, 2014), and 'interaction' to describe the statistical event whereby the observed joint effect, when X and Z are both present, deviates from that expected on the basis of their independent effects.

3.3.2 RATIONALE SUPPORTING THE ROLE OF EFFECT MODIFIER

The role of an effect modifier does not have to be causally related to the association being modified (Szklo & Nieto, 2014), it is instead a statistical phenomenon which may or may not have a health pathway underpinning it. In the context of this thesis, it is possible that social participation and musculoskeletal pain interact so that sufficient levels of social participation may 'switch off' or dim the negative impact of musculoskeletal pain on mental/physical health in older people. If proven to be the case, social participation would be a useful way to identify groups of older people who are likely to maintain their health despite musculoskeletal pain from those who are at high risk of a deterioration in health.

Social participation may be an effect modifier, with different magnitudes (or absence) of musculoskeletal pain-health associations found in older people reporting similar social participation characteristics. For example, people who adopt an adaptive response to chronic pain are less likely to report depression than those who express more distress in response to their pain and have lower levels of social support (Angst et al., 2008). It may be that people who pursue and maintain social participation despite having musculoskeletal pain are more adaptive, or that higher levels of social support are accumulated through such activities. Confidante relationships (e.g. those with close friends) have been shown to moderate the negative impact of stressful events (e.g. loss of a spouse) upon both mental and physical health (Bookwala et al., 2014). The stress-buffering hypothesis was originally suggested to be a mechanism by which social support can improve physical health outcomes by reducing negative stress appraisals and weakening the association between stress and negative health outcomes (Uchino, 2006). Musculoskeletal pain may be hypothesised as a potential health stressor, so it is plausible that social participation may buffer the impact of musculoskeletal pain upon health.

Older people who maintain social participation despite pain may experience less interference on other aspects of their daily life. Musculoskeletal pain interference on normal activities, including social roles, has been found to moderate the success of interventions for depression upon mental health in older people (Mavandadi et al., 2007b). Subsequently frequent social participation may be maintained most often by those older people who are more likely or able to successfully self-manage their musculoskeletal pain and maintain their health. Coping strategies demonstrated by older people with musculoskeletal pain are generally stable over time (Regier & Parmelee, 2015), and more active strategies are associated with better health and wellbeing (Perrot et al., 2008;Rapp et al., 2000). Maintaining social participation may also buffer the negative impact of musculoskeletal pain by facilitating a maintained sense of self-identity and encouraging perseverance with daily activities and adherence to self-management strategies (Ong et al., 2011). It has also been shown that pain variability is influenced by factors such as the availability of social support and social activities (Cederbom et al., 2014), with low levels of social integration being linked to greater impact of pain on daily life (Lacey et al., 2014;Waltz et al., 1998).

3.3.3 EMPIRICALLY TESTING FOR EFFECT MODIFICATION

In this thesis, assessment of interaction between pain and social participation was used to test for an effect modification by social participation. Unlike other methods applied in cohort studies, such as stratification, this method enables the sample to be assessed while controlling for putative confounders (Szklo & Nieto, 2014). The process involves first running an analysis which includes both the exposure and posited effect modifying variables, and then testing for a statistical interaction by adding a multiplicative term (exposure X effect modifier) as a new variable (Marsh, et al., 2013). If the interaction term coefficient is statistically different to zero, then an interaction is said to be present (Hayes 2013). However, if the null hypothesis of no interaction is rejected, this information alone does not determine which variable is substantively interpreted as the focal predictor and which is the effect modifier, unlike stratification for example. (The theory underpinning tests for effect modification is provided in Appendix 5.) Advantages of the interaction term approach include a single test of statistical significance for effect modification within the sample, and inferences from findings being generalizable to the whole sample population, whereas in stratified analyses inferences may be generalised only to the sample stratum they arise from, not the entire original sample (van Ness & Allore, 2004). The interaction effect of a binary effect modifier can be probed further by examining the coefficients with the binary effect modifier reverse-coded to obtain the conditional effect of the exposure on the outcome for the alternate effect modifier status.

In quantitative analyses, power refers to the probability of correctly rejecting the null hypothesis if there is truly no effect. In the context of effect modification analyses, low power means it is more likely that findings will erroneously retain the null hypothesis of no moderating effect, when Z is in fact a true effect modifier. Low sample size has been identified as one of the main causes of loss of power in multiple regression analyses examining moderating effects (Aguinis, 1995). Unequal subgroup proportions have an even greater effect on power than that of total sample size (Aguinis, 1995). The effective total sample size is determined by the smallest subgroup sample size, because regardless of the total sample size, as subgroup proportions become less equivocal the statistical power to detect the effect modifier declines (Aguinis, 1995). In this study efforts were made to ensure subgroups had sufficient participants. For example, infrequent and moderate socialisers were combined to provide an adequate referent group for comparison with frequent socialisers with high community engagement and frequent socialisers with low community engagement respectively.

Multigroup analysis was used to further probe differences between social participation groups if significant statistical interaction was found. Multigroup analysis, or multiple group analysis, is a specific way of examining heterogeneity of effects across subgroups defined in terms of the proposed effect modifying variable. It is similar, but theoretically distinctive, to simple stratification, where a sample is divided into groups according to their moderating variable data, and each subgroup analysed in isolation of the others (Muthén & Muthén, 2015). Multigroup analysis can control for covariates in the total sample and by subgroups (Muthén & Muthén, 2015), and enables differences in effect significance and direction for covariates to be compared across subgroups. The main advantage of multigroup analysis, over simple stratification, is that it incorporates information from the overall sample when generating parameter estimates (e.g. confidence intervals) (Muthén & Muthén, 2015). When using relative measures such as odds ratios or relative risks the effect is not directly comparable across strata, as the association of the reference group may also differ in each stratum (Marsh, et al., 2013). However, stratified analyses methods, such as multigroup analysis, may be regarded as providing greater descriptive information, at the level of effect modifier subgroups, within the broader context of the theoretical model (Kraemer, et al., 2002). Each model was run with the parameters for all included independent variables allowed to vary across groups and the role of each independent variable examined. Whilst constrained and unconstrained multiple group models could have been compared to test for the presence of effect modification (Vrieze, 2012), this study used interaction terms, as this method has higher statistical power.

3.4 SOCIAL PARTICIPATION AS A CONFOUNDING VARIABLE

3.4.1 DEFINING CONFOUNDING VARIABLES

The role of confounding variable is perhaps the most widely recognised and understood of the third variable roles, and the importance of controlling for confounding variables is well documented in epidemiological literature (Szklo & Nieto, 2014; Huang & Bandeen-Roche, 2004). Confounding may manifest in various ways dependent on the strength and direction of relationships between an exposure, and outcome and a third variable (Spicer, 2005). Confounding is sometimes considered a special case of bias, and occurs due to a third variable which is not on the causal pathway between the exposure and outcome (Szklo & Nieto, 2014). The effect of an exposure on an outcome may spuriously appear, be suppressed, inflated or deflated in magnitude, or even change direction, due to confounding. Confounding effects arise when a confounding variable is unevenly distributed across groups being compared, and can threaten the validity of estimated effects between an exposure and outcome in cohort studies (Szklo & Nieto, 2014). To be conceptualised as a confounding variable, it is necessary (McNamee, 2003), but not always sufficient (Shrier & Platt, 2008), for a variable to meet the following criteria:

i) to cause or be a marker of a cause of the outcome in unexposed cases;
ii) to cause or be a marker of a cause of the exposure, but not caused by the exposure;
iii) to be distributed unequally among the groups, defined in terms of the exposure, that are being compared.

Figure 3:2 illustrates how social participation may confound the association between musculoskeletal pain and health. Social participation is hypothesised as a cause, or a proxy marker of an upstream cause, of both pain and health. This scenario results in a spurious association [A] between musculoskeletal pain and health if social participation is distributed unevenly between musculoskeletal pain groups.

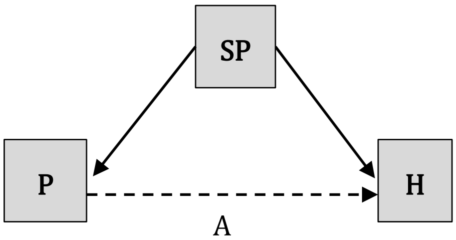


Figure 3:2 Directed acyclic graph illustrating social participation (SP) as a confounder of any association between musculoskeletal pain (P) and health (H). Source: Original

Whilst strategies for controlling for confounding may be implemented during study design before data gathering (i.e. restriction, randomisation or matching), this is not possible in studies such as this one, which employ secondary data analysis. Such studies are restricted to strategies used during statistical analysis to control for confounding, i.e. stratification and adjustment in multivariable methods. Using stratification to account for confounding entails grouping cases so that levels of the putative confounding variable do not differ within stratum. However, if there are many strata or multiple confounding variables, stratification is often unsuitable (Szklo & Nieto, 2014). This is because with each additional confounding variable there is a sharp rise in the number of strata required to create groups with a single level of each putative confounding factor. Multivariable methods control for confounding by including confounding variables in the model so that the unique variance in the outcome explained by the confounding factor is accounted for (Szklo & Nieto, 2014).

An association between an exposure and outcome will not be confounded if any confounding variables are adequately controlled for.

A third variable may be an effect modifier, a confounder, both or neither. However, if it is an effect modifier, it is inappropriate to simply control for it and provide the adjusted coefficients. This is because the coefficient for the exposure will still differ at differing values of the effect modifier, and so the group-level estimation will be influenced by the within-group heterogeneity of effect (Szklo & Nieto, 2014). Differentiating between confounding and the role of effect mediation is conceptually driven, as both explain the relationship between the exposure and outcome. However, a confounding variable is extrinsic to the causal process (i.e. not on the causal pathway), while an effect mediator is intrinsic to the causal process (i.e. sits on the path between exposure and outcome). Therefore, correctly conceptualising the third variable has important consequences for the resulting findings and their inferences.

3.4.2 RATIONALE SUPPORTING THE ROLE OF CONFOUNDER

Firstly, for social participation to be conceptualised as a confounding variable, it must cause or be associated with mental and physical health in older people *without* musculoskeletal pain. Whilst evidence that the association between social participation and health may be causal are discussed in later sections, many studies have reported social participation to be associated with subsequent health in general older population samples. Restricted social participation has been linked cross-sectionally to increased odds of reporting depression, anxiety, high blood pressure and heart problems (Wilkie et al., 2007), and maintaining social engagement has been linked to better mental health and reduced physical disability (Golden et al., 2009; Baum et al., 2000). Secondly, social participation must cause or be a marker of a cause of musculoskeletal pain. Evidence in support of this second confounder criterion is more ambiguous. Whilst it has been suggested that musculoskeletal pain results in restricted social participation in older people (Wilkie et al., 2013; Ekstrom et al., 2008), there is also evidence to suggest that many older people maintain physical activity and social participation despite musculoskeletal pain (Moore et al., 2014; Ong et al., 2011).

Finally, social participation must be distributed unequally among those with and without musculoskeletal pain. Studies examining associations between social participation and pain suggest those without musculoskeletal pain are less likely to report limited social participation (Docking et al., 2015; Gignac et al., 2013). Therefore, as social participation is independently associated with both musculoskeletal pain and health, it is possible that it may result in spurious associations between musculoskeletal pain and health outcomes being found in observational studies. In this case social participation would be a confounding variable.

3.4.3 EMPIRICALLY TESTING FOR CONFOUNDING

The magnitude of confounding for a given variable can be quantified by computing the difference between the crude and adjusted measures of the effect of the exposure on the outcome. This is tested for using a series of multivariable regression models. First the model is run without the putative confounder included. Then the putative confounder (i.e. social participation) is added as a covariate, and the magnitude of confounding attributable to the confounder quantified by calculating the difference in odds ratios between the initial and adjusted effect size. Relying on statistical significance to identify a confounding variable is discouraged (Szklo & Nieto, 2014). The effect of a confounding variable may itself be confounded by other variables, and so may differ between samples depending on the distribution of other confounders between the groups being compared. Therefore, it is recommended that putative confounders be kept in multivariable models regardless of their statistical significance (Szklo & Nieto, 2014). However, erroneously controlling for a collider variable, that is a variable which is an effect of both the exposure and outcome, can actually introduce bias into parameter estimates (Szklo & Nieto, 2014). For this reason, putative confounders were included in the analytical models testing social participation in each of the possible third variable roles, so as to mitigate as far as possible the confounding effect of other variables upon the findings.

3.5 CHAPTER SUMMARY

No single, definitive statistical method exists by which to determine which of the possible third variable role(s) social participation fulfils. Both theoretical and conceptual considerations are important when developing an analytical strategy for identifying the role of a third variable. A strength of this thesis is that the each of the three possible third variable roles are empirically tested in the same cohort and using the same variables. This will enable the evidence supporting or refuting each proposed role to be compared more easily, and the findings will contribute to what is known about the role of social participation in maintaining mental/physical health in older people with musculoskeletal pain. For effect mediation, this will be done by decomposing the total effect (c) into the direct effect (c') and indirect effect (ab) to enable the effect of pain on mental/physical health through social participation to be examined. The role of social participation as an effect modifying variable will be statistically deduced by examining the effect of pain on mental/physical health in respect to levels of social participation. This will be performed by assessing for interaction between pain and social participation, and using multigroup analyses to probe further any interaction identified. Finally, the role of confounding variables will be tested for by examining any difference between models when the putative confounder is present and absent respectively.

CHAPTER FOUR: SYSTEMATIC REVIEW

4.1 CHAPTER OVERVIEW

This chapter reports on the systematic search and critical review of the literature performed to fulfil objective 2 of the thesis; to identify existing empirical evidence examining social participation as an effect mediator or effect modifier of associations between musculoskeletal pain and mental and/or physical health conditions in older people.

4.2 INTRODUCTION TO THE SYSTEMATIC REVIEW

The aim of the review was to identify previous empirical research examining the role of social participation as an effect mediator and/or effect modifier of the association between musculoskeletal pain and mental and/or physical health conditions in older people. A 'scoping study' approach was adopted (Kitchenham & Charters, 2007), with the focus being on identifying what studies have examined the role of social participation as either an effect mediator or effect modifier, rather than on identifying a specific outcome or effect as is normal practice in systematic reviews (Sutton et al., 1998). The following objectives were used to achieve the review aim:

1. To identify and describe previous empirical studies testing the role of social participation as an effect modifier/mediator of the association of musculoskeletal pain and mental/physical health conditions in older adults.

2. To identify the theoretical mechanisms drawn upon by these studies to explain the role of social participation as either an effect mediator or effect modifier in their study.

4.3 METHODS

4.3.1 SEARCH STRATEGY

The first stage of the literature review was to develop and pilot an effective search strategy. The search strategy was developed with reference to population, interventions, comparators, outcomes and study design (PICOS; CRD, 2009) Table 4.1.

Table 4:1 The PICOS elements of the review and how they were targeted in the search strategy

PICOS element	Method by which they were targeted
Participants - Older people	**Application of exclusion criteria** – Studies with a mean study population age of <60 years or which did not report age-stratified results for older age subgroups were excluded.
Intervention/exposure – Social participation and musculoskeletal pain respectively	**Search components**- S#1 sought to identify studies which examined social participation (as either an exposure or an intermediary variable). S#2 sought to identify studies which examined musculoskeletal pain as an exposure.
Outcome – Physical and/or mental health	**Application of exclusion criteria** – Studies where the hypothesis did not relate variation in social participation to physical or mental health conditions in those with pain were excluded.
Study design – Empirical studies	**Application of exclusion criteria** – Studies which were not empirically based were excluded.

The search strategy consisted of two search components for social participation (S#1) and musculoskeletal pain (S#2) respectively. Searches were performed in title and abstracts, and included key words relating to social participation and musculoskeletal pain respectively, relevant Medical Subject Headings (MeSH) were also used. For S#1, the key words were: social participation, social engagement, social function*, social activit*, social roles, participation restriction, participation impairment, social handicap, community involvement, community integration. MeSH terms included: Social participation, Leisure activities/leisure activity/recreation and Community role/social participation. For S#2, key words were used to identify pain which was explicitly musculoskeletal as well as pain types which are known to be primarily musculoskeletal in origin (i.e. widespread pain and non-cancer pain). These were: musculoskeletal pain, widespread pain, chronic pain, neuralgia, arthritis, arthralgia, fibromyaligia, backache, arthr*, osteoartr*, OA, degenerative joint(s), myalgia, radicular pain, regional pain, multi* pain, comorbid* pain, 'non-cancer pain', 'non-malignant pain', 'complex regional pain syndrome' and specific localised pain terms (i.e. back, hip, knee, neck, shoulder, foot). MeSH terms included: Rheumatic diseases, arthritis, arthralgia and musculoskeletal diseases. The results for S#1 and S#2 were combined (using Boolean operator 'AND'). Filters were used where available to restrict findings to English language. Due to the different structures and organisation of each database and variation in the indexing utilities available, search strategies were individually tailored to each database. Additional relevant articles were sought by searching the reference lists of full-text articles included in the review. The specific search strategies and citations yielded are detailed in Appendix 2. This strategy follows recommended good practice to effectively identify studies answering the review aim (CRD, 2009; Sutton et al., 1998), e.g. by combining and incorporating appropriate search tools and Boolean logic. Prior to the full literature search being carried out, the proposed search strategy was piloted on a single database (AMED). After reviewing the number of retrieved citations, and their applicability to the research question, the strategy was deemed fit for purpose with only minimal amendment necessary to improve the inclusivity of the text terms included within the social participation component[2].

4.3.2 DATABASE SELECTION

A broad range of databases were searched from database inception to January 2014 (Table 4:2). Chosen databases reflected the fact that both social participation and the role it fulfils in determining health transcend different medical and sociological disciplines. Three key medical databases were searched; EMBASE, MEDLINE, and British Nursing Index (BNI), as were three allied health and psychology databases; Allied and Complementary Medicine (AMED), Cumulative Index of Nursing and Allied Health (CINAHL), and PsychINFO. Then the Cochrane Database and Database of Abstracts of Reviews of Effects (DARE) were searched to identify any relevant systematic reviews. Additionally, a specialist gerontology database, AGELINE, was searched, as were selected sections of Web of Science. Grey literature, including dissertations and theses, were searched via three internet search platforms; OpenGrey, Electronic Theses Online Service (EThOS), and ProQuest. The databases were initially searched in January 2014. EBSCO was used to search AGELINE, and NHS Evidence HDAS for AMED, CINAHL, EMBASE, MEDLINE and PSYCHINFO. A search of OpenGrey and EThOS was performed on 23/01/2014, followed

[2] 'social function*' was added as an additional search term

by ProQuest on 24/01/2014. A search of the reference lists of included full-text papers was then performed. The individual citations yielded by each search were downloaded into separate folders within Refworks 2.0 where duplicates were identified and removed.

Table 4:2 Description and search period for all databases searched during the systematic review

Database	Description	Period searched
EMBASE	Biomedical database with over 25 million indexed records from thousands of peer-reviewed journals	1974- present day
MEDLINE	United States based database, containing over 19 million references to journal articles in life sciences	1950- present day
British Nursing Index	UK focussed database covering 250 key English language nursing and midwifery journals	1985-present day
Allied and Complementary Medicine	Database indexing over 400 English and European journals focussing on allied health professions	1985-present day
Cumulative Index of Nursing and Allied Health (CINAHL)	US focused database indexing over 1,200 nursing and allied health journals and theses	1981- present day
PsychINFO	Comprehensive database of all areas of psychology drawn from over 2000 international journals	1806- present day
Cochrane Database	A collection of six databases compiled by the Cochrane Collaboration, the NHS Centre for Reviews and Dissemination, and others)	1994 - present day
Database of Abstracts of Reviews of Effects (DARE)	Database of randomised control trials (RCTs)	1898 -present day
AGELINE	Database which indexes over 200 sources of both published and grey literature covering age-related issues	1978- present day
Web of Science	An extensive social science based collection of research data, books, journals and other publications. The indices selected were the Science Citation Index Expanded (SCI-E), Social Sciences Citation Index (SSCI), and the Science (CPCI-S) and Social Science and Humanities (CPCI-SSH) Conference Proceedings Citation Indices.	SCI-E, 1970-present day SSCI, 1970 – present day CPCI-S and CPCI-SSH both 1990 – present day
OpenGrey	A European based resource covering doctoral dissertations, conference papers and other grey literature	inception – present day
Electronic Theses Online Service (EThOS)	The UK's national thesis service covering over 400,000 records of UK Doctoral theses	inception – present day
ProQuest	A search platform focussed on North American and European dissertations and theses	1990-present day

4.3.3 STUDY SELECTION

Eligibility criteria were deliberately kept broad to maximise the likelihood of identifying relevant studies within the databases. The inclusion criteria were: 1) the article must be freely available in English, and 2) the article must report a human study. Studies were excluded if: 1) the study did not report empirical research findings, 2) the study hypothesis did not relate variation in social participation to the association between musculoskeletal pain (as defined in search strategy #2) to physical or mental health outcomes, 3) the study did not measure exposure to musculoskeletal pain or was related to pain which was likely malignant in origin, 4) the study did not specifically report on older people, or 5) the article was not freely available to the researcher. Exclusion criteria are listed in Table 4.3, which was used as a formal checklist by SB for screening the titles of all articles identified by the search. Any that clearly met the criteria were excluded.

Table 4:3 Screening tool used to identify which studies met the exclusion criteria

Target item	Exclusion criteria
1. Study Type	The study is not empirically based
2. Study Hypothesis	Study hypothesis does not relate variation in social participation to physical or mental health conditions in those with musculoskeletal pain
3. Exposure	Musculoskeletal pain is not measured for the study sample, or relates to pain which is likely malignant in origin (e.g. cancer pain)
4. Population	Does not specifically report on older people (as evidenced by a minimum mean study population age of ≥60 years or reported age-stratified results for older age subgroups)
5. Availability	Article is not freely available via the research institute resources (e.g. library and public domain)

The first review of abstracts was undertaken by one reviewer (SB), again using the screening tool shown in Table 4:3. A random sample of 20% of the abstracts was then independently screened by a second reviewer (RW). Agreement beyond chance between the two reviewers was assessed using unweighted Cohen's Kappa statistic (Cohen, 1968). Any disagreements were resolved through discussion and consensus. Articles retained following abstract screening were then obtained in full and screened independently by the two reviewers (SB and RW) to determine those which met the criteria for inclusion in the review. Reference and citation checks were carried out on all retained papers to check for any additional relevant studies. This is a time efficient way of identifying key papers which may be missed by electronic searches (Sutton et al., 1998).

To update the review, a supplementary search was performed for each database on 22/05/16 to check for any articles published between 01/01/2014 and 22/05/16. Additionally, a PubMed search of the first authors of all retained full texts was performed on 29/05/16, with no date restriction applied, to check for any additional relevant articles. The abstracts of any additionally identified articles were then reviewed by a single reviewer (SB). The full-texts of any additional, relevant articles retained following abstract screening were reviewed in full against the selection criteria, independently by two reviewers (SB & RW).

4.3.4 QUALITY APPRAISAL AND DATA EXTRACTION

Quality appraisal and data extraction were performed on each article by a single reviewer (SB).

Quality appraisal

First a comprehensive summary checklist was applied to each article for quality appraisal. The checklist covered multiple aspects of study design, conduct, analysis and conclusions (e.g. quality of design, methodological rigour and trustworthiness of conclusions). It was adapted from a list developed by Kitchenham & Charters (2007) and informed by several medical research review guidelines. The quality checklist, along with the respective information for included studies, is provided in Table 4.5, Section 4.3.4.

Data extraction

Data addressing the review objectives were extracted using a purposely designed data extraction tool. The tool captured key study features, including study type, hypotheses tested, statistical analyses performed, sample characteristics and key findings. Some fields were free text (e.g. author, title and study hypothesis) and others had pre-assigned categorical values (e.g. study type, study design and the role of social participation examined) (Table 4:4). The range of information collected was broad and descriptive in nature to reflect the review objectives, i.e. identifying the extent to which social participation had previously been examined as an effect mediator or an effect modifier and identifying the theoretical models underpinning the hypotheses. The generic data extraction tool was first applied and tested for practicality and feasibility by SB on two papers. Results of this initial data extraction were then appraised independently by RW to ensure data adequately reflected the content of the papers, as recommended by Clapton et al (2009) so that tools can be adjusted before main data extraction (Clapton et al., 2009). The tool was deemed adequate for its purpose and no amendments were necessary. The full sample of selected papers was then processed by SB and the extracted data were checked for omissions and accuracy by RW.

Table 4:4 Data extraction tool used to summarise identified studies

Study features

- Identification features of the study: article title, author(s), year of publication, publication, country of origin and study purpose
- Participant characteristics: Study sample size, demographic characteristics, subgroup size and comparability, recruitment method, inclusion and exclusion criteria
- Definition of musculoskeletal pain and health outcome: pain measurement tool, proportion with pain, study outcome and outcome measurement tool
- Social participation: definition and measurement tool
- Hypothesis
- Role of social participation tested
- Statistical technique used to study the role of social participation
- Nature of effect found
- Confounding factors accounted for
- Overall conclusion

4.4 RESULTS

4.4.1 SEARCH RESULTS

A total of 7,358 articles were identified by the initial search, of which 1,802 were duplicates and subsequently discarded, leaving a total of 5,556 unique items (Figure 4:1). Details of the number of citations yielded for each search strategy, and number of duplicates is provided, by database, in Appendix 2. The titles of these papers were all screened, and on this basis 558 were retained, and 4,999 excluded.

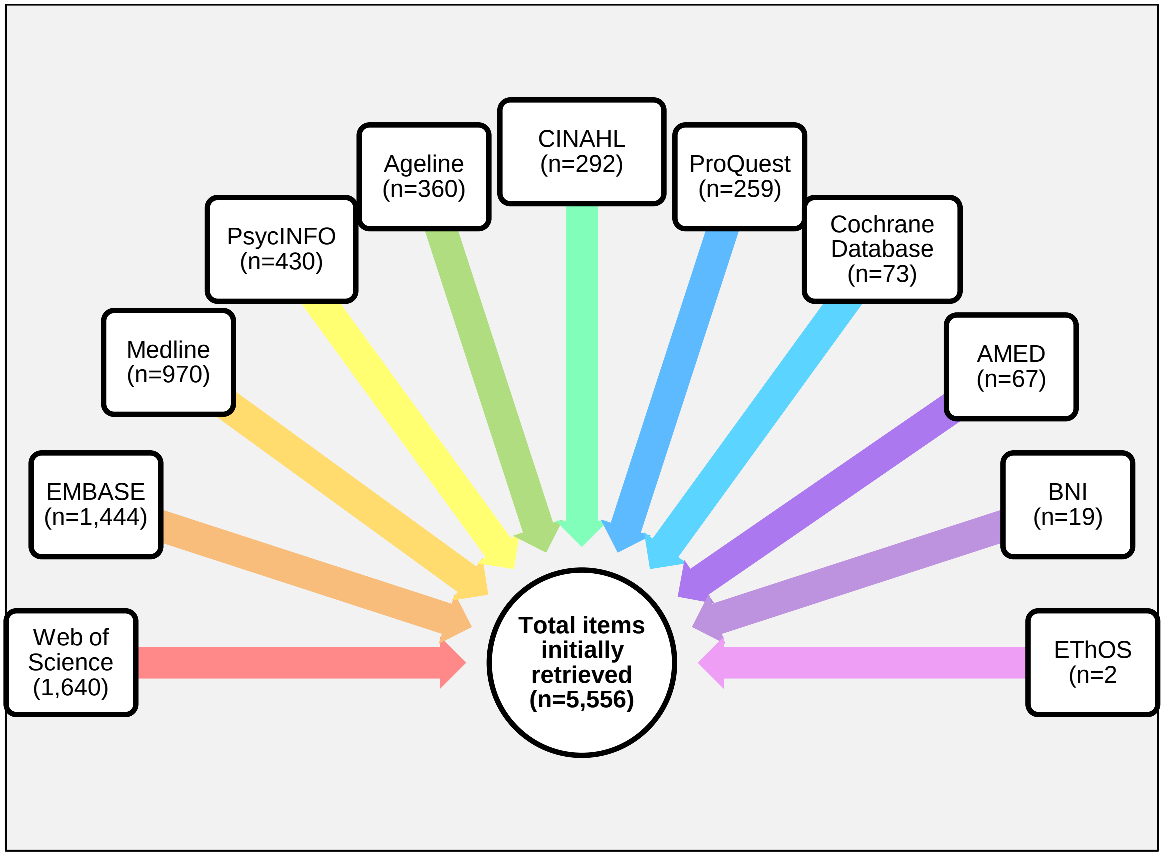


Figure 4:1 Number of items retrieved during initial systematic database search, sequenced in order of quantity contributed

The 558 retained abstracts were screened by SB. A 20% random sample (n=112) was selected for independent screening by the second reviewer (RW). Agreement on inclusion/exclusion of 110 papers by both reviewers reflected a Cohen's Kappa statistic (k) of 0.824 (95% CI: 0.585, 1.000), indicating high inter-rater reliability (Sim & Wright, 2005). Following discussion, full consensus was met on the remaining two articles in the repeatability sample.

Full text versions of the 23 articles selected by the abstract review process were then obtained, and these were read and assessed against the criteria for inclusion/exclusion by two reviewers independently (SB and RW). There was agreement on 22 of the 23 for inclusion or exclusion and disagreement on 1. Disagreement was resolved by discussion, resulting in 3 being retained for the final review. Agreement was reached on 2 further papers for inclusion following a subsequent search update in May 2016. The PubMed search of first authors from retained articles yielded 415 citations[3], none of which were retained. A flow chart of the study selection process is provided in Figure 4:2.

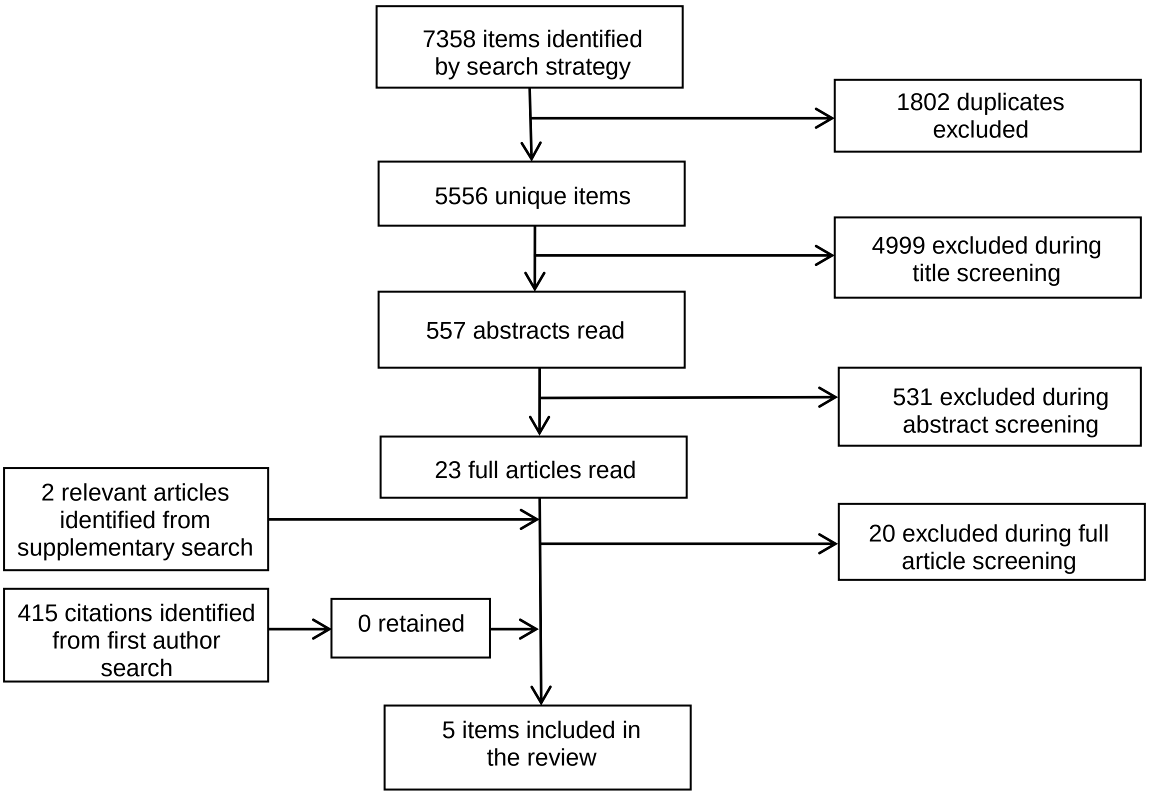


Figure 4:2 Flow chart of study selection

[3] Blyth FM=149, López-Lopez A=140, Mavandadi S=40, Parmelee PA=48, Tang NK=38

4.4.2 INCLUDED STUDIES

Five studies were included in the review. These are summarised in Table 4.5 below with a critical synthesis of the studies reported in section 4.4.4.

Table 4:5: Summary of the characteristics of the studies included in the systematic review (Part A)

Study	Study design (n=) and role of social participation	Summary of relationship examined (PICO format[4])	Measure of social participation	Summary of musculoskeletal pain and health outcome(s) measures	Statistical technique used to examine SP and summary of study findings
Blyth et al., (2008)	Observational, cross-sectional health survey (n=8881) SP examined as an **effect moderator**	P: community dwelling, ≥65 years I: pain/ care-giving C:no pain and no care-giving O: Psychological distress	Caregiving roles measured via single self-report question; 'Do you have the main responsibility in caring for someone who has a long term illness, or disability or other problem?'	Pain: any pain lasting ≥ 3/12 in preceding 6/12 Health outcome: anxiety and depression via Kessler 6	Stratified logistic regression analyses and interaction term Care-giving was significantly associated with psychological distress independently of pain. A significant interaction was found between care-giving and pain
Lòpez-Lopez et al., (2014)	Observational, cross-sectional interview study (n=208) SP examined as an **effect moderator** and an **effect mediator**	P: community and nursing –home dwelling older adults ≥65 years I: OA related pain intensity C:- O: Depressive symptoms	2 components of 7 areas of functioning covered social participation: 'family relationships and social activity'. The overall score was representative of participation.	Unclear how pain presence determined. Pain intensity measured using a composite measure of current, worst, least and average pain. Health outcome: depressive symptoms- Geriatric depression scale, cut-off of 14	Moderation- regression and addition of interaction term in last step. Moderated mediation- following Hayes guidelines for moderated mediation. Both activity limitation (AL), pain and ALxPain were significant in the final moderation model ($p<0.01$) for both of the groups. This effect appeared to be modified by extent of pain interference however. In community dwellers AL partially mediated the effect of pain on mental health.

[4] Huang et al., (2006). Evaluation of PICO as a knowledge representation for clinical questions. AMIA Annual Symposium Proceeds; 359–63

Table 4:5 Summary of the characteristics of the studies included in the systematic review (Part B)

Study	Study design (n=) and role of social participation	Summary of relationship examined (PICO format)	Measure of social participation	Summary of musculoskeletal pain and health outcome(s) measures	Statistical technique used to examine SP and summary of study findings
Mavandadi et al., (2007)	Prospective, longitudinal health survey (n=597) SP examined as an **effect mediator**	P: community dwelling, ≥65 years I: pain C:no pain O: Depressive symptoms	Positive/ negative social interactions measured using PANSE (24 items measuring positive and negative social exchanges)	Pain: Presence of bothersome pain (? Time frame) Health outcome: depressive symptoms via CES-D	Structural equation modelling Pain was significantly associated with negative exchanges, and both pain and negative exchanges predicted greater depressive symptomatology over time. Positive social exchanges, however, were not related to either pain or depression
Parmelee et al., (2007)	Prospective longitudinal health survey (n=293) SP examined as an **effect mediator**	P: older individuals with OA knee I: pain C:no pain O: Depressive symptoms	Discretionary activity participation/limitation- items from Multilevel Assessment Inventory Activities Scale and AIMS 2 social activity scale	Pain: general pain symptoms (6 item Philadelphia geriatric centre pain scale) Health outcome: depressive symptoms via CES-D	Path analysis & Baron and Kenny mediation criteria. Only activity participation was independently associated with depression over the course of 1 year. Activity limitation and activity participation are not polar opposites but distinctive measures of social factor characteristics
Tang et al., (2015)	Prospective longitudinal health survey (n=6676) SP examined as an **effect mediator**	P: adults ≥50 years registered with 1 of 6 North Staffordshire GP practices I: Pain lasting 1 day or longer. ‘ C: No pain O: Insomnia symptoms	Reduced social participation was measured using the Keele Assessment of Participation (KAP),	Blank body manikin (front and back views) with pain lasting for 1 day in the past month identified. Categorised as no/some/widespread Insomnia- Jenkins Sleep Questionnaire. Symptoms ‘some of the time’ or more	Path analysis and the Karlson Holm Breen method of decomposition was adopted to separate the total effect in a logistic model into direct (some and widespread pain) and indirect (physical limitation and reduced social participation) effects. The proportion of mediation is calculated by dividing the indirect effect by the total effect.

4.4.3 QUALITY APPRAISAL

There was variation between the articles included in the review in terms of the methodological rigour demonstrated and the information provided. The quality appraisal data for each included article is summarised in Table 4.6 below.

Study design and conduct

All studies clearly identified the study purpose, although the Parmelee paper did not state the precise hypothesis. Transparency of analyses is highly important when reporting scientific findings (Jack et al., 2010). Participant recruitment methods differed between studies. Three of the studies recruited participants using probability sampling (randomised or whole population), where the probability is known; and the same across a group of individuals. The other two studies (Lopez-Lopez et al., 2014 and Parmelee et al., 2007) used purposive sampling, a non-probability method which is likely to introduce selection bias (Jack et al., 2010). The rationale for not using probability sampling, and possible limitations arising, were not discussed by either of these studies. The use of a non randomised sample increases the risk of confounding, which if unaccounted for during analyses can reduce the chances of correctly identifying effect mediation or effect modification (MacKinnon, et al., 2002). All but the Blyth paper provided the final response rate, which ranged between 65%-91%.

Each of the studies selected suitable measurement tools, defined variables in a way which enabled the research question to be addressed, and adequately described how variables were defined. However, variables generated from these measures were not always treated according to best practice. Mavandadi and colleagues (2007) used a 4 point score as a continuous variable, potentially threatening the validity of the study findings. Treating count level data as continuous is not recommended, especially if it demonstrates a skewed distribution and/or is bound by zero as it often violates assumptions in parametric analyses (Sweet & Grace-Martin, 2011).

Analysis and conclusions

All studies provided adequate descriptions of the statistical analyses used. All studies tested statistical significance as part of their analyses, but only two (Parmelee et al., 2007; Blyth et al., 2008) reported the actual p-values as good practice recommends (Kitchenham & Charters, 2007). All but one study included putative confounders as covariates in their analyses to control for any influence on study findings. This is recommended practice to attenuate bias and compromise introduced by confounding variables (Jack et al., 2010). Only Mavandadi et al., (2007) did not report controlling for any confounders, but this study did include baseline depression and social interaction status in the final model, and considered gender as an effect moderating variable.

Two papers clearly presented baseline characteristics between groups using a table format (Tang et al., 2015 and Blyth et al., 2008), but only one (Tang et al., 2015) included baseline characteristics, beyond age and gender, which could influence study findings. Reporting of baseline characteristics is especially important in studies looking at between group differences (Jack et al., 2010), such as that entailed in testing for effect mediation/moderation. None of the studies provided statements to describe any consideration of appropriate sample sizes (e.g. sample size calculations or post hoc power analyses). This is an important consideration, as whilst the power of the overall effect may be adequate in studies with a large sample, small subgroup sizes can significantly diminish the power of between group comparisons, especially in complex analytical models such as those used to test for effect modification and effect mediation (MacKinnon et al., 2014; Brookes et al., 2004). This was a particular concern in the article by Blyth et al., (2008) which, although having an overall sample size of 8881 participants, had groups ranging in size from 30 to 6411 in a single model. Furthermore, the total number of participants in some models did not equal the number provided in the first line of the result section, suggesting that they were complete case analyses.

Generally, the studies each presented findings which answered the study research question. However, as Parmelee et al., (2007) did not clearly state their research objective or hypothesis, it was difficult to ascertain if this was achieved in that study. Overall the study findings enabled the reader to clearly identify whether or not social participation was identified as being an effect modifier or effect mediator. In the case of Mavandadi et al., (2007), which identified a non-significant effect, the null findings were interpreted.

Table 4.6 Summary of quality appraisal data for papers included in the review (Part A)

	Blyth et al (2008)	López-Lopez et al (2014)	Mavandadi et al (2007)	Parmelee et al (2007)	Tang et al (2015)
Design					
Are the aims clearly stated in the abstract or introduction?	Y	Y	Y	N	Y
What role of SP is stated as being examined? Effect mediator (Me) / Effect moderator (Mo)	-	Mo, Me	Me	Me	Me
Was the data collected with these questions in mind?	N	Y	N	N	?
Do the study measures allow the question to be answered?	Y	Y	Y	Y	Y
Were the inclusion criteria clearly stated in the text?	N	Y	N	N	Y
Were the exclusion criteria clearly stated in the text?	N	Y	N	N	Y
How was the sample obtained? (Postal (P), Interview(I), Medical Records (MR), Other (O)	I	I	I	P&I	P
Were participants selected from the entire population (E), randomly (R), purposively (P) or self-selecting (S)?	R	P	R	P&S	E
Is there a comparison or control group? No (-), No pain (NP), Other (O)	O	-	-	-	NP
Are baseline characteristics clearly reported for comparison groups?	N	-	-	-	Y
Are the variables used relevant for answering the research question?	Y	Y	Y	Y	Y
Are the variables used adequately measured? (i.e. valid and reliable)	Y	Y	Y	Y	Y
Are the measures used in the study fully defined?	Y	Y	Y	Y	Y
Is the size and length of the study sufficient to allow for changes in the outcomes of interest to be identified?	some groups small	small sample	Y	only 2 time points	only 2 time points
Conduct					
Are the data collection methods adequately described?	Y	Y	Y	Y	Y
If longitudinal is the proportion/number of participants lost to follow-up given?	-	-	Y	Y	Y
Analysis					
What was the response rate? (f=at final time point)	?	91%	f65%	f79%	f71%
Was the exact denominator (population) size reported?	N	N	Y	N	Y
Do the researchers explicitly state the data type for all key variables? Continuous, ordinal, binary etc	N	N	N	N	N
Are the study participants adequately described? E.g. age, gender etc	Y	Y	Y	Y	Y
Are the statistical methods for moderation/mediation described? Yes (Y), Poorly (P), No (N)	Y	Y	Y	P	Y
Is the statistical program used to analyse the data referenced?	Y	Y	Y	N	N

Table 4:6 Summary of quality data for papers included in the review (Part B)

	Blyth et al (2008)	López-Lopez et al (2014)	Mavandadi et al (2007)	Parmelee et al (2007)	Tang et al (2015)
Analysis (cont.)					
Are the statistical methods used to test for moderation/mediation appropriate?	Y	P	Y	P	P
For testing effect mediation, how many time points are used?	-	1	3	2	2
Is the purpose of the analysis clear?	Y	Y	Y	N	Y
Are the overall scoring systems for key variables described?	Y	N	N	Y	Y
Are potential confounders adequately controlled for in the analysis?	Y	Y	P	Y	Y
Are participant characteristics presented in table format?	N	N	N	Y	Y
Do the numbers add up across the different tables and subgroups?	N	-	-	N/A	Y
Are differences between group characteristics statistically tested for?	N	Y	Y	Y	Y
Are attempts made to control for differences between groups? (e.g. adjustment for confounders?)	Y	Y	N	Y	Y
Was statistical significance assessed?	Y	Y	Y	Y	Y
If statistical tests are used to determine differences, is the actual p value given?	Y	N	N	Y	N
If the study is concerned with differences between groups, are confidence intervals given describing the magnitude of any observed differences?	Y	-	-	N	Y
Is there evidence of multiple statistical testing or large numbers of post hoc analyses?	N	N	N	N	N
Is selection bias likely? Yes (Y), Maybe (M), No (N)	N	M	N	M	M
Conclusions					
Are all the study questions answered?	Y	Y	Y	N	Y
What role of SP, if any, was identified? Effect mediator (Me), Effect moderator (Mo), Neither (N)	N	Mo, Me	Mo	-	Me
Are the SP role findings negative?	N	N	Y	N	N
Are any null findings interpreted? (e.g. possibility of small sample size)	-	-	Y	-	-
Is the practical significance/ implication of the findings clearly discussed?	-	Y	Y	Y	Y
Are limitations of the study identified and discussed?	Y	Y	Y	Y	Y
Are limitations and implications of any differences between drop-outs and participants specifically discussed?	-	-	N	Y	N
Are limitations arising due to problems with the validity/reliability of measures specifically discussed?	Y	Y	Y	N	Y
Y= Yes, N=No, P= partially					

4.4.4 SYNTHESIS OF STUDY FINDINGS

This section summarises the findings of the review with reference to the objectives which were to: 1) identify and describe previous empirical studies testing the role of social participation as an effect modifier/mediator of the association of musculoskeletal pain and mental/physical health conditions in older adults., and 2) identify the theoretical mechanisms drawn upon to explain the role of social participation as either an effect mediator or effect modifier of the association between musculoskeletal pain and health outcomes in older people.

4.4.5 MODERATION ANALYSES

Two articles examined social participation as an effect modifier, both were cross-sectional in design. One used interaction terms to test for effect modification of the association between musculoskeletal pain and depressive symptoms (López-Lopez et al., 2014), the other reported supplementary analyses which stratified by caregiving status when examining the cross-sectional association between musculoskeletal pain and depressive symptoms/self-rated health respectively (Blyth et al., 2008). Overall, the studies did not provide sufficient evidence to support or refute social participation as an effect modifier of the association between musculoskeletal pain and subsequent mental/physical health in older people.

In the study by Blyth et al., (2008), one explanation of the null effect may be the small sample sizes of the three caregiver groups with varying degrees of pain interference (n=30,60 and 30 respectively) relative to the referent group (n=6411) (Bryan & Jenkins, 2013). Unlike the negative findings of the Blyth paper, Lopez-Lopez and colleagues (2014) found an improvement in model fit with the addition of an interaction term between pain and activity restriction into their model predicting depressive symptoms, indicating effect modification; in stratified analysis in those reporting little activity restriction, the association between musculoskeletal pain intensity and depressive symptoms was not significant, whilst a strong and significant association was found between musculoskeletal pain and depressive symptoms in those who did report restricted activity. The between group difference in significance of pain-depression association again suggests the grouping variable (i.e. activity restriction) to be an effect modifier.

Comparison of the findings across the two studies was difficult due to the differences between them. Neither of the identified studies operationalised social participation consistent with the specific definition identified by Levasseur and colleagues (2010) and used in this thesis. Blyth and colleagues (2008) examined the specific social role of caregiving, and the Lopez-Lopez and colleagues (2014) used 'activity', defined consistent with the concept of participation, which included social activities and family relationships. Caregiving roles are one specific aspect of social participation, which have been suggested to represent a stress or strain on daily life in older adults (Pinquart & Sörensen, 2007;Mehta, 2005), and participation is a broader concept than social participation alone, so these studies are unlikely to provide a precise measure of the role of social participation as an effect modifier[5]. A recent systematic review exploring barriers to social participation in caregivers (Pinto, 2016) found evidence that caregivers may participate in fewer voluntary social activities, experience reduced quality of life and report worse health,

[5] The conceptual difference between 'social participation', 'participation' more broadly, and specific social activities (i.e. caregiving) is discussed in detail in Chapter 2; Section 2.5.

compared to non-caregivers. The findings of this review suggest that the type of social activities constituting social participation (e.g. caregiving versus visiting friends/family) may be a more important factor to consider when evaluating the role of social participation in determining health than overall frequency of social activities in isolation.

Overall, the number of empirical studies that have examined the role of social participation as an effect modifier of the association between musculoskeletal pain and mental or physical health conditions is small. Despite many studies suggesting that musculoskeletal pain and social participation are closely linked, and that both predict subsequent health (Benka et al., 2016; Saastamoinen et al., 2012;Holmes & Joseph, 2011;McBeth et al., 2009), only two studies have tested the hypothesis that social participation may modify the association of pain on health. Neither study operationalised 'social participation' in line with the conceptual model proposed by Levasseur (2010).

4.4.6 THEORETICAL RATIONALES UNDERPINNING INCLUDED STUDIES

Neither Blyth and colleagues (2008) nor Lopez-Lopez and colleagues (2014) drew upon established models of health as underpinning their respective hypothesis. Blyth and colleagues (2008) provided a concise rationale for their study, highlighting a lack of evidence describing the combined impact of pain and caregiving upon older people as the rationale for their study. They built their argument around the theory that the combined impact of two distinctive risk factors for poor health (stress from care-giving roles) and musculoskeletal pain may differ from that of each risk factor in isolation, implying that the two may interact when impacting upon the health of older people. Lopez-Lopez and colleagues (2014) highlighted a lack of evidence describing the relationship between musculoskeletal pain, activity restriction and depression, and cited preliminary evidence from an earlier study (Williamson & Schulz, 1992) which suggested physical disability has a modifying effect on the association of musculoskeletal pain on depression in community samples. They identified that, although both musculoskeletal pain and social participation restriction are known risk factors for health, the precise relationship between the two is unclear and the studies examining this topic often yield conflicting findings. In summary, only two studies were identified that provide empirical evidence of effect modification by social participation (or associated factors) on the association between musculoskeletal pain and subsequent mental/physical health measures in older people. This may be due, in part at least, to a lack of a clearly established theoretical model positing how and why social participation may fulfil such a role.

4.4.7 MEDIATION ANALYSES

Four articles examined social participation as an effect mediator, including the Lopez-Lopez (2014) paper which also tested social participation as an effect modifier. The approaches adopted to test for effect mediation varied, with the Lopez-Lopez study using a cross-design and the Mavandadi, Parmelee and Tang studies using longitudinal analyses. The differences in statistical models used to test for effect mediation reflects the lack of consensus within health and social research on how best to test for effect mediation (Lui et al., 2016; Gelfand et al., 2009).

Reporting of the analyses and the results also varied. Parmelee et al., (2007) cited Baron and Kenny's steps to mediation as the intended method. The authors' application of such analyses was not easy to follow, and presented results did not clearly relate to the expected steps. Some parts of the manuscript seemed to suggest that pain was modelled as the mediator rather than being the independent variable[6]. Furthermore, the extent of effect mediation by the three mediator variables was unclear as it was not reported in terms of proportion of the total effect explained by the indirect effect through the mediator.

The putative confounders included in the respective models varied, limiting the ability to make across-study comparisons of any mediating effects. Of the four articles, the outcome of interest for three of them was depressive symptoms (López-Lopez et al., 2014;Mavandadi et al., 2007;Parmelee et al., 2007), and the other examined insomnia (Tang et al., 2015). Although diverse measurement tools were employed to capture social participation, the measures of three were conceptually fairly similar, capturing the broader concept of participation (Tang et al., 2015; López-Lopez et al., 2014; Parmelee et al., 2007). The other study (Mavandadi et al., 2007) captured positive and negative social exchanges, which included multiple domains of social activities (e.g. companionship, exchange of social support and lack of social interaction with others). None of the studies conceptualised social participation in accordance with the model identified by Lavasseur and colleagues (2010) and used in this thesis.

Those studies which considered physical activity limitation or restriction provided evidence to suggest that social participation is distinctive from physical activity when considering factors affecting the association between musculoskeletal pain and health

[6] Page 456: 'This mediating effect of pain in the association of activity limitations with depression was confirmed by a Sobel test (z=3.82, P<.001)'.

outcomes. Lòpez-Lopez et al., (2014) found activity limitation was a partial effect mediator of the association between musculoskeletal pain and depressive symptoms for the overall sample, and in community dwelling older people. Similarly, Parmelee et al., (2007) found both physical disability and activity limitation explained some of the impact of musculoskeletal pain upon subsequent mental health. Parmelee and colleagues (2007) reported a significant (negative) indirect effect of musculoskeletal pain on depressive symptoms through activity participation, and an insignificant (positive) effect through activity restriction. Unlike Parmelee et al., Lopez-Lopez and colleagues (2014) found activity restriction to be a significant, partial effect mediator of the association between musculoskeletal pain and depressive symptoms. Parmelee also found activity participation to be an independent predictor of mental health, independent of that of musculoskeletal pain. Tang et al., (2015) reported that physical limitation is a stronger effect mediator of the relationship between widespread pain and insomnia in older people than social participation restriction, although social participation restriction remained a weak effect mediator even when included in the same model as physical activity limitation. The indirect effect through social participation restriction was small, (with a standardised β coefficient of 0.02), compared to that of physical limitation (standardised β coefficient 0.25). These findings support the model posited in this thesis which suggests that social participation is distinctive from physical activity. Mavandadi and colleagues (2007) did not find pain to significantly predict subsequent negative or positive social exchanges in longitudinal analyses, and neither variable was a significant effect mediator of the longitudinal effect of pain on depressive symptomology. Cross-sectionally musculoskeletal pain did not predict positive social interactions, but did predict negative social interactions. This difference in significance in the role of a positive measure of social participation compared to a negative measure (i.e. restriction or limitation) was also found in the Parmelee study, where activity participation was associated with depression independently of musculoskeletal pain but activity limitation and functional disability were not. These findings support the conceptualisation of social participation in this thesis as a construct in its own right, rather than as the polar opposite of social participation restriction. In the Mavandadi study the measures of social interactions (i.e. positive and negative) included companionship, the exchange of social support and lack of social interaction (neglect). However, social exchanges, while a useful proxy of social participation, may better be defined as a consequence of social participation rather than a direct measure. Overall, there was weak evidence suggesting social participation to be an effect mediator. This was not consistent across studies, even those sharing the same health outcome. Furthermore, no study operationalised social participation consistent with the definition adopted by this thesis. Further research examining social participation as an effect mediator of the association between musculoskeletal pain and mental and physical health is needed.

4.4.8 THEORETICAL RATIONALES UNDERPINNING INCLUDED STUDIES

Mavandadi and colleagues (2007) hypothesised that social interactions may mediate the effect of pain on depressive symptoms because pain may negatively impact upon social support and fulfilment of social roles. They proposed that pain is a source of acute stress, which can increase the social support demands of the individual to beyond that which their social support network can accommodate, as well increasing the frequency of negative exchanges with others which increases distress, anger and dissatisfaction with social interactions. Consistent with other researchers (e.g. Chiao et al., 2011;Forsman et al.,

2011) Mavandadi and colleagues (2007) suggested that positive exchanges with others may buffer against the negative impact of pain, and so help to maintain mental health. The hypothesis that social participation may act as a buffer, attenuating the negative impact of musculoskeletal pain on subsequent health, is consistent with that posited by this thesis.

The Lopez-Lopez and Parmelee articles highlight that little consensus has been reached as to how musculoskeletal pain, participation restriction and depressive symptoms inter-relate. They acknowledge previous research which suggests musculoskeletal pain can lead to a reduction in participation, and suggest this can lead to emotional distress, and subsequently depressive symptoms. They address the research gap by testing whether participation restriction is an effect mediator (and in the case of the Lopez-Lopez article also effect modifier) of the effect of musculoskeletal pain upon depressive symptoms.

Unlike the other studies testing for effect mediation, Tang and colleagues (2015) suggest that social participation (and physical limitation) are responsible for generating sleep-pressure and entraining circadian rhythm, both of which are important mechanisms underlying normal sleep patterns. They hypothesis that musculoskeletal pain may lead to increased prevalence of insomnia by reducing physical activity and restricting social participation, which in turn decreases the build-up of sleep pressure and disrupts normal circadian rhythm. In this theoretical model, unlike that of the other studies, social participation does not act as a buffer mitigating the impact of musculoskeletal pain upon subsequent health. Instead the model posits that musculoskeletal pain results in a reduction in social participation, which then leads to reduced sleep pressure and thus insomnia. However, such a theoretical model is not able to explain why some older people with musculoskeletal pain maintain their health despite pain if one accepts the evidence presented by the Parmelee and Mavandadi studies, that social participation is not the polar opposite of restricted social participation. The rationales for the Lopez-Lopez, Parmelee and Tang articles all refer to a need to build upon, and better understand, current evidence of associations between musculoskeletal pain, social participation and depressive symptoms/insomnia respectively.

4.5 DISCUSSION

The studies identified in this review suggest social participation may partially mediate the relationship between musculoskeletal pain and poor health but overall there is no conclusive evidence about social participation as an effect modifier of the association between musculoskeletal pain and mental and physical health. Few studies met the inclusion criteria of the review, and of those that did all but one studied mental health outcomes. None of the studies examined the role of social participation in maintaining good health, instead they focused only on the occurrence of poor health. Despite an acceptance that social participation is associated with maintaining good health in older people (AgeUK, 2014; ARUK, 2014; Bowen et al., 2014), few studies have examined it empirically in terms of being an effect modifier or effect mediator of good health in those with musculoskeletal pain. Additionally, effect mediation and moderation are relatively new concepts (MacKinnon & Luecken, 2008), and so are often under-utilised, mis-specified and/or misinterpreted (Jung, 2014; MacKinnon et al., 2014).

There may be other studies that have examined the role that have used different terminology and methodology for testing for, effect modification (Shahar & Shahar, 2010). This makes identifying such studies challenging. Negative findings are less likely to be published (Fanelli, 2010), and so this may be another reason why few studies are available. Social participation is a complex construct, with no gold standard measurement instrument yet identified, and so differences in the methodological approaches taken to measuring social participation and the aspects of social participation they capture are likely to influence the probability of negative findings.

4.5.1 CRITIQUE OF THE SEARCH STRATEGY

This review took a broad, scoping study approach to identifying relevant literature. For example, it was not restricted to studies using the term 'social participation', but also included those which used associated terms (e.g. social exchanges). As the definition of 'older people' is inconsistent between studies, the target population (i.e. general older populations) was not specified in the search strategy. Neither were terms for effect mediation/moderation operationalised in specific search strategies, as such terminology is often used inconsistently, and to do so would have been likely to lower the sensitivity of the search strategy. To increase the likelihood of identifying relevant articles a search of grey literature was performed via three internet search platforms, in addition to the searches of databases of peer-reviewed articles.

The large number of papers excluded in the title search is likely to be influenced by the broad search strategy. To provide confidence that papers were not excluded inappropriately, a random selection were checked, and agreement levels between the two reviewers, experienced with the concept of social participation, was high. One way to increase the likelihood of identifying any additional studies examining the role of social participation as an effect mediator or effect modifier may have been to read the abstracts of all citations yielded before excluding any irrelevant studies, rather than using a title screening step. Tests for effect modification and mediation may be tested in secondary analysis and in subsamples, so may not be described in the abstract. However, pursuing relevant articles in the bibliographies of included articles, and general searching of the evidence base through the course of the PhD, failed to identify any additional articles suitable for inclusion, supporting the adequacy of the review search strategy.

The inclusion and exclusion criteria were selected to be as inclusive as possible, whilst addressing the review aims. For example, no search strategy was used to identify 'older people' specifically, and studies were included during screening if mean age was lower than 60 years as long as results were stratified by age. The low number of studies meeting the study selection criteria, and variation in their respective conclusions regarding the role of social participation, has implications when trying to draw a consensus from the review findings. For example, the two studies examining effect modification provided very different conclusions. However, had more studies examining effect modification been identified it may have been easier to determine if a consensus existed between them towards social participation having a significant effect modifier role, or not. Similarly, the studies identified predominantly examined mental health outcomes, with little evidence of the role of social participation in determining which older people with musculoskeletal pain maintain physical health being identified.

The review did not grade included studies following quality appraisal, or seek to exclude poor quality research. This may potentially bias the review findings as methodological merits and flaws of each study are not necessarily considered when synthesising the evidence. However, identifying a specific association effect size or direction was not an objective of this review. The primary objectives were to identify and describe studies that have examined the role of social participation as an effect modifier or mediator in older people with musculoskeletal pain, rather than determining direction or size of effects. Therefore, the quality of a study was not considered a serious threat to the validity of the review findings. Evidence for the role of confounder was not sought as the significance and direction of any confounding effect are not routinely reported for confounding variables, and confounding may be accounted for during the randomisation stage of randomised controlled trials (Jepsen et al., 2004).

4.5.2 GENERALISABILITY OF THE FINDINGS OF INCLUDED STUDIES

The target populations of the included studies broadly reflected the population of interest in this thesis; with all but the Lopez-Lopez study studying community dwelling older people. The recruitment strategies applied in some studies were likely to influence the representativeness of the study sample. The Lopez-Lopez study sought to recruit community dwelling and nursing home residents, and had strict inclusion criteria which is likely to have added to selection bias. Limiting the study population to participants with no serious chronic illness (except for musculoskeletal problems, type 2 diabetes and hypertension) and no functional impairment other than that relating to musculoskeletal problems makes the validity of the findings to older people questionable as the target population was older people. Older age and residing in a nursing home are both associated with increased levels of ill health and functional impairment (Luppa et al., 2010; Wolff, et al., 2002). Similarly, the generalisability of findings from a study of older people without any serious chronic illness across the general, community dwelling older population is questionable. It is likely that those meeting such inclusion criteria were healthier on average than those who did not.

There was wide variation in how both musculoskeletal pain and social participation were defined and measured between studies. Measures varied from multi-dimensional composite pain scores (López-Lopez et al., 2014; Parmelee et al., 2007), through body manikins (Tang et al., 2015), to a simple, 4-point scale question capturing pain frequency (Mavandadi et al., 2007). This has implications for the synthesis of evidence as the way musculoskeletal pain is measured and defined influences parameter estimates, and the interpretation of findings. For example, Blyth and colleagues (2008) considered only pain which had been present every day for 3 months or longer. This is likely to exclude those with more transient pains, or recurrent episodic pain which would be captured with less stringent pain measurement tools. A long history of musculoskeletal pain may increase the likelihood of depression, as each symptom has been shown to increase the likelihood of reporting the other (Arnow, et al., 2006), and so defining pain in this way could strengthen the observed main effect of musculoskeletal pain on depressive symptoms. Furthermore, only Tang et al (2015) used a measure of pain validated to measure musculoskeletal pain specifically. Consequently, it is likely that the some pain will arise from non-musculoskeletal sources.

As discussed previously, the confounding variables considered and approach taken to control for them varied between studies. Most of the studies considered putative confounders and included them in regression models to control for their effect. However López-Lopez and colleagues (2014) took extreme caution during recruitment, by setting stringent exclusion criteria. The criteria included some symptoms which would be expected in older people with chronic musculoskeltal conditions, e.g. 'any degree' of sensory impairment, serious chronic illness other than musculoskeletal problems, type 2 diabetes and hypertension and a Charlson Comorbidity Index score >1 (excluding age score). Therefore it is likely that the samples, particularly the nursing-home subset, would not be representative of the target population. Many nursing home residents have multimorbidity (Wolff, et al., 2002).

Variations in statistical methods used to test for effect mediation made comparison across studies challenging. The variety of approaches used reflected the range of techniques available and lack of consistency in statistical methods used within research. This arises in part due to a lack of consensus on the best ways to test for effect mediation, although the importance of determining causality rather than just correlation is widely acknowledged (Preacher, 2015; Hayes, 2013). When testing for effect mediation, cross-sectional analyses are not recommended or deemed good practice (Maric et al., 2012; Roe et al., 2012). However, cross-sectional mediation analyses continue to be found in recent publications (Liu et al., 2016). Of the included studies which examined for effect mediation only one, Lopez-Lopez et al (2014), used cross-sectional data, while the other three used longitudinal data. A limitation of using 2 or fewer time points is that the effect mediator must either be measured at baseline or at the same time as the outcome. The inferences of cross-sectional analyses therefore are limited to identifying correlation, and provide weak evidence of causal relationships (Preacher, 2015). It has also been shown that cross-sectional analyses of effect mediation are more likely to find a substantial indirect effect, even when the true longitudinal indirect effect is zero (Maxwell & Cole, 2007). Consequently, it is possible that in the Lopez-Lopez study the partial effect mediation of the association between musculoskeletal pain and depressive symptoms for the overall sample and in community dwelling older people, and the full mediation effect found in nursing-home dwellers may be spurious, or inflated away from the null. While it may be argued that activity limitation is theoretically likely to be an intermediary in a causal chain between musculoskeletal pain and depressive symptoms, the lack of temporal sequencing between variables means further research is needed to replicate these findings in longitudinal datasets. The power to reliably determine effect mediation demonstrated by these studies is likely to be low, due to general poor adherence to mediation analysis best practice and, in some cases, small sample sizes.

4.6 CHAPTER SUMMARY

Following a comprehensive, systematic search of the literature, 5 papers were identified that examined the role of social participation as an effect moderator or effect mediator in the association between musculoskeletal pain and mental and physical health. Both fulfilment and restriction of social participation were examined overall, with both activity participation and restriction being independently found to have a significant association with health outcomes. This review highlights a research gap. Little research has examined whether social participation is an effect mediator/modifier of the association between musculoskeletal pain and health outcomes in older people, and of studies which have examined this topic, none have considered how social participation might determine which older people with musculoskeletal pain maintain their health. Further research examining the role of social participation in determining the association between musculoskeletal pain and mental and physical health in older people is needed.

CHAPTER FIVE: THE ENGLISH LONGITUDINAL STUDY OF AGEING (ELSA)

5.1 CHAPTER OVERVIEW

This chapter is split into two parts. Firstly, the English Longitudinal Study of Ageing (ELSA) is introduced. This is the UK older population cohort from which empirical data used for the secondary analyses in this thesis was obtained. This introduction provides an overview of data collection methods, sampling techniques for the survey and the response rates. Secondly, the ELSA items used to measure the exposure and outcomes of interests in this thesis are described in more detail, including details of the selection of suitable proxy measures and an examination of the ELSA items used to obtain the relevant data, including empirical tests of underlying assumptions. (A measure of social participation was developed using multivariate analysis, and is discussed in Chapter Five.)

5.2 INTRODUCTION TO THE STUDY SAMPLE

5.2.1 THE ENGLISH LONGITUDINAL STUDY OF AGEING

Two challenges of epidemiological studies are the need for large sample sizes (Fritz & MacKinnon, 2007) and the time duration which must elapse between data collection waves to enable longitudinal analyses to be performed (Bowling, 2014). To address these challenges in this thesis, secondary analysis of data already collected as part of ELSA was utilised. ELSA is a large-scale longitudinal panel study, with repeated measures collected from a cohort of community-dwelling older people at regular, two-yearly intervals. ELSA was specifically selected because it provides a comprehensive range of relevant data collected from people aged ≥50 years, and is representative of the English older population (Steptoe et al., 2012). ELSA was chosen over other similar cohorts, such as the General

Lifestyle Survey, as it asks about pain specifically and includes a number of questions relating to social participation captured repeatedly at multiple two-yearly waves. As described in Chapter Two social participation is a complex, multi-dimensional concept, and ELSA provides a broad range of measures capturing both formal and informal social participation activities, as well as detailed health and sociodemographic information (Steptoe et al., 2012), providing a rich data resource for addressing the thesis research objectives.

ELSA data is designed and collected by a collaborating team of researchers from the Department of Epidemiology and Public Health at University College London, the Institute for Fiscal Studies, the University of Manchester and the National Centre for Social Research (Cheshire et al., 2012). The purpose of ELSA is to make available a comprehensive collection of longitudinal data which enables research questions relating to older people preparing for and moving into retirement and old age to be investigated (Steptoe et al., 2012). Data for wave 1 were collected in 2002/03, with two-yearly follow-ups thereafter, and a nurse visit and biomarker assessment every four-years (Cheshire et al., 2012). The main interview takes the form of a personal interview using CAPI (computer-assisted personal interview) followed by a short self-completion questionnaire. The study also includes a life-history interview collecting information on lifetime family circumstances, details on the place of residence, employment and major health events prior to the baseline interview (Cheshire et al., 2012). The nurse visits are performed on a subsample of participants, and involve measurements of physical function, anthropometric measurements and blood/saliva samples (Cheshire et al., 2012). For those participants who are known to have died, an end of life interview is carried out with close friends/relatives of the eligible ELSA respondent who has died to collect information about the respondent's circumstances in the period since the final interview and their death (Cheshire et al., 2012). Data from ELSA were downloaded from the UK Data Service website following registration with the UK data service (at https://discover.ukdataservice.ac.uk/series/?sn=200011#access). The variables presented in ELSA were screened, and those required for this thesis prepared and recoded as necessary by SB. The coding for all statistical models were developed and run by SB, who then interpreted and reported the findings.

5.2.2 ELSA SAMPLING FRAME

The ELSA sample was selected from households that had previously responded to the Health Survey for England (HSE), which employed a clustered stratified probability sampling technique (Cheshire et al., 2011). The HSE was designed to be nationally representative of private households by selecting a random probability sample of households from all those available in the Postcode Address File (Mindell et al., 2012). The households sampled in ELSA are representative of England in terms of the degree of urbanization and deprivation (Prior et al., 2003), and respondents were selected to be representative of the UK older population in terms of age and gender (Steptoe et al., 2012). Eligibility criteria were: membership of a participating household from HSE in which at least one person had agreed to follow-up, born before 01/03/52 and living in a private household in England at the time of the first wave of fieldwork (Cheshire et al., 2011). The sampling frame of households participating in HSE in 1998/1999 and 2001 provided a large sample size of 23,132 households (NatCen, 2012). In 2000 the HSE survey focussed on adults over 65, so this year was not used in generating the ELSA sampling frame.

Refreshment samples were used at Waves 3 and 4 to maintain representation of those in their early 50s. These were people sampled from the HSE from 2001 to 2006 who were previously too young to take part in ELSA (Steptoe et al., 2012).

Of all those eligible to take part in ELSA at Wave 1, the response rate was 64.7%. A total of 11,391 interviews were achieved with age-eligible sample members (or core members) at the first wave of data collection. Spouses aged under 50 were also included in the data collection, giving a total baseline (Wave 1) sample of 12,099 people (Steptoe et al., 2012). Refreshment samples were added first at Wave 3 to maintain the representation of people aged 50–53 years, and then additionally at wave 4 to maintain the representativeness to the 50–75 age group (Steptoe et al., 2012). Figure 5:1 shows a flow diagram of the ELSA sample recruitment and longitudinal data collection from Wave 1 to 4.

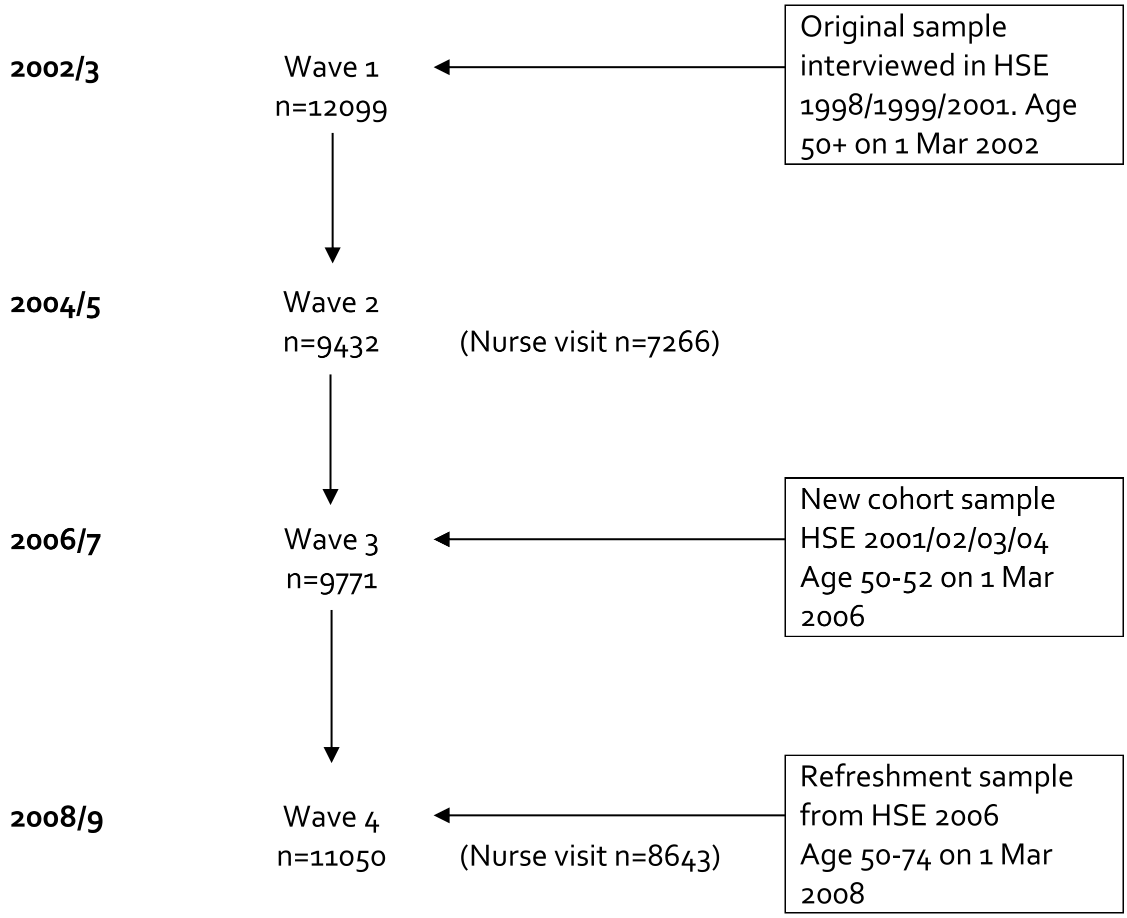


Figure 5:1 Participant flow diagram showing data collection in ELSA Waves 1 to 4. Source: original (Sample sizes are for the complete ELSA study)

Response to the survey was encouraged by an offer of a £10 gift voucher to be provided at the end of the interview. In subsequent waves, individuals were assigned the same interviewer where possible, and where members of households were no longer living together attempts were made to contact responders at both old and new addresses. This ensured that as far as reasonably possible all those eligible for the ELSA study had the opportunity to take part. If an individual was unable to take part as a result of cognitive impairment or illness, a proxy interview was attempted with an informant. This was usually a family member, but could be anyone over the age of 16 who could provide the relevant information about the individual (Cheshire et al., 2012). If the self-completion questionnaire was not returned a reminder was sent, and if this was also unsuccessful a member of the NatCen Telephone Unit would call the respondent and complete the form on their behalf from their answers provided via telephone (NatCen, 2012).

5.2.3 ELSA WAVES USED IN THIS THESIS

ELSA is ongoing, with data collection at two-yearly intervals. This thesis utilised data from a total of three time points: 2004, 2006 and 2008. Wave 2 of ELSA (2004) provided the baseline measures for cross-sectional analyses (data from this wave is referred to as 'baseline' in subsequent chapters). In all analyses reported in this thesis, whether cross-sectional or longitudinal, the variables for musculoskeletal pain and any covariates (e.g. sociodemographic characteristics and baseline health status) were those measured at Wave 2 of ELSA. The longitudinal analyses reported in Chapters Seven and Eight used outcome and social participation data from more than one ELSA wave. Analyses to test for effect modification drew upon social participation data from Wave 2 of ELSA and health outcome data from Wave 3 of ELSA (2006). Thus Wave 3 of ELSA was referred to as 'two-year follow-up'. Data from 2008, ELSA Wave 4, was used to provide the third timepoint needed to test for effect mediation. In these analyses, additional social participation data were drawn from ELSA Wave 3, and health outcome data drawn from ELSA Wave 4, subsequently referred to as 'four-year follow-up'. This information is summarised in Table 5:1.

Using two time-points enabled any interaction between baseline social participation and musculoskeletal pain in determining subsequent health to be examined as part of tests for effect modification. When testing for effect mediation three time points were necessary to examine whether a change in musculoskeletal pain over time preceded a change in social participation, and subsequently a change in health. As complete-case analysis was used, the exact sample size for a given analysis was determined by the number of individuals providing the necessary information, therefore a description of the samples is provided in the corresponding chapter.

Table 5:1 Summary of the ELSA Waves used to provide information for the respective analyses reported in this thesis

	ELSA Wave 2 (Thesis baseline)	ELSA Wave 3 (Thesis two-year follow-up)	ELSA Wave 4 (Thesis four-year follow-up)
Identifying distinctive social participation groups			
Musculoskeletal pain	X		
Social participation	X		
Mental/Physical health	X		
Other descriptive factors	X		
Examining the role of social participation as an effect modifier (of the respective health outcomes)			
Musculoskeletal pain	X		
Social participation	X		
Mental/Physical health		X	
Covariates	X		
Baseline mental/physical health status	X		
Examining the role of social participation as an effect mediator			
Musculoskeletal pain	X		
Social participation	X	X	
Mental/Physical health			X
Covariates	X		
Baseline mental/physical health status	X		

5.3 EMPIRICAL INVESTIGATION OF ASSUMPTIONS FOR PRIMARY VARIABLES

As this thesis undertook secondary data analysis, the choice of data contributing to analyses was dictated by what information was captured in the ELSA survey. Section 5.3 considers how the primary variables (i.e. musculoskeletal pain as the exposure, and mental and physical health as outcomes), were measured, reporting descriptive analyses performed to test any assumptions underpinning their selection.

5.3.1 MUSCULOSKELETAL PAIN

Musculoskeletal pain is the exposure of interest in this thesis. While a question or measure validated for capturing musculoskeletal pain in health surveys, e.g. a pain manikin (van der Hoven et al., 2010), would have been ideal, no such measures were available in the ELSA dataset. After careful consideration of the available items the response of ELSA respondents to the question 'are you often troubled with pain?' was used as a proxy measure for musculoskeletal pain. The question captures the ongoing/recurrent nature of chronic musculoskeletal pain through the use of 'often troubled', thus excluding those with one-off aches and pains which have weaker associations with long-term health or social participation. Single question items are commonly used to identify musculoskeletal pain in health studies (Litcher-Kelly, et al., 2007), and enable sufficient information to be obtained while posing minimal participant burden (Younger, et al., 2009).

This question was chosen over questions targeting specific body locations (e.g. back pain and knee pain) as it encompassed the whole body. The individual location questions in ELSA captured only back, hips, knees and feet (Cheshire et al, 2011), and musculoskeletal pain elsewhere, e.g. shoulder pain or hand pain, were not included, nor were conditions such as fibromyalgia and tendonitis (NatCen, 2012). To further justify this choice, the underlying assumption (i.e. that most of those responding to the question in ELSA 'Are you often troubled by pain?' were affected by musculoskeletal pain) was tested empirically by comparing the response to this question with the responses to the regional pain questions (see 5.3.1.1 below).

There was one other option for measuring musculoskeletal pain in ELSA. Additional items relating to the participants' own report that they had received a diagnosis of specific musculoskeletal pain-related conditions (e.g. arthritis) were available in ELSA. These items require respondents to report contact with health care and a diagnosis (i.e. the questions were phrased 'has a doctor ever told you that you have…' (NatCen, 2012)). This presents several problems if choosing to use self-reported receipt of a medical diagnosis to define the presence of musculoskeletal pain. Firstly, older people expect aches and pains as part of getting older (Paskins et al., 2014; Richardson et al., 2014) so may not consult their primary care practitioner. In fact, it has been estimated that over a 12 month period a quarter of people aged >55 years will have an episode of persistent knee pain, but only about one in six of them consults their general practitioner about the problem (Peat et al., 2001). Secondly, medical professionals may use a variety of terms to talk about conditions such as osteoarthritis with their patients, and sometime may not formally diagnose arthritic conditions (Bedson et al 2004). For example, GPs have reported withholding a diagnosis of osteoarthritis or degenerative arthritis, using 'wear and tear' in preference, to avoid upsetting the patient or to prevent the adoption of a 'sick role' and increased disability (Paskins et al., 2014). Thirdly the correlation between the clinical diagnostic markers often used to confirm a clinical diagnosis (e.g. changes identified on radiographs) and reported symptomatology is weak (Hunter & Felson, 2006; Bedson and Croft 2008). This works in both directions. The prevalence of painful osteoarthritis among older adults is lower when only clinically diagnosed disease is used rather than self-reported joint pain (Hunter & Felson, 2006; Mazzuca et al., 2003). For example, the prevalence of knee osteoarthritis is estimated at 40% in older adults, but drops to 10% when based upon clinical diagnosis (Joern et al., 2010). But if the diagnosis is only based on the presence of radiographic change, then many people may have this diagnosis and not have musculoskeletal pain. For example, a study of 1062 older people participating in the Framingham study (Leveille et al, 2005) found that 35.6% of women and 27.5% of men reporting no pain had osteoarthritis of the hand and knee (defined in terms grade >2 on the Kellgren/Lawrence scale), and only about 15% of patients with radiologically demonstrated knee osteoarthritis complain of knee pain (Hannon et al., 2000).

These limitations around using specified musculoskeletal diagnoses, such as osteoarthritis, as a marker of chronic pain in the community are clearly demonstrated in the technical report (Adomaviciute et al., 2015) describing the work underpinning the Arthritis UK National Musculoskeletal Calculator7. The calculator used data from the ELSA cohort to create a model to predict the prevalence of musculoskeletal pain in England overall and by region, which was then developed into an interactive online tool. Adomaviciute (2015) reported that of those reporting a diagnosis of hip osteoarthritis, 991 also had hip pain while 2717 had no hip pain. Similarly, of those reporting a diagnosis of knee osteoarthritis 1546 reported knee pain and 2162 reported no knee pain. Due to the discrepancy between diagnosed osteoarthritis and reporting pain for the purpose of the predictive model Adomaviciute and colleagues defined 'empirical hip/knee osteoarthritis' as those who reported knee pain, regardless of whether or not a diagnosis of osteoarthritis was reported.

For this thesis it was proposed that the single question, 'Are you often troubled by pain?', would represent the most appropriate item to capture pain of musculoskeletal origin for the purpose of this study. This assumption (i.e. that most of those responding to the question 'Are you often troubled by pain?' in ELSA were affected by musculoskeletal pain) has been examined (see below) in the ELSA dataset by estimating and presenting the association between the response to the question about doctor-diagnosed arthritis and the response to the single question 'Are you often troubled by pain'?

EMPIRICALLY TESTING THE ASSUMPTION THAT TROUBLESOME PAIN IS A PROXY FOR MUSCULOSKELETAL PAIN IN ELSA

Responses to the question 'Are you often troubled by pain?' were examined against a new variable, named 'Musculoskeletal Pain', derived for the purposes of this analysis from multiple ELSA items. ELSA did not include a method of identifying musculoskeletal pain originating from all parts of the musculoskeletal system, but the survey did ask about pain in the back, hips, knees and feet when walking on a flat surface (as four individual questions). These questions were only asked of those respondents who reported being often troubled by pain. Using questions related to specific body locations in this way is similar to the use of pain manikins in health surveys, whereby identification of pain in the area around a given joint is interpreted as arising from the muscles, bones and soft tissues in that area (Nakamura et al., 2014; Van der Hoven et al., 2010).

The flowchart below (Figure 5.2) shows how ELSA respondents were coded for the derived variable for this validation analysis. Those who reported no troublesome pain, or had troublesome pain but no pain in their back, hips, knee and/or feet, were coded as having no musculoskeletal pain. Therefore, the 'no musculoskeletal pain category' included those for whom a musculoskeletal origin of their pain could not be established from the limited items within ELSA. Those with troublesome pain AND pain in one or more of the specific sites (i.e. back, hips, knees and feet) were coded as having musculoskeletal pain. Previous research of pain in older people suggests that most chronic or ongoing musculoskeletal pain reported by older people is related to the back, hip, or knee (Fejer and Ruhe, 2012; Croft et al., 2010; p205).

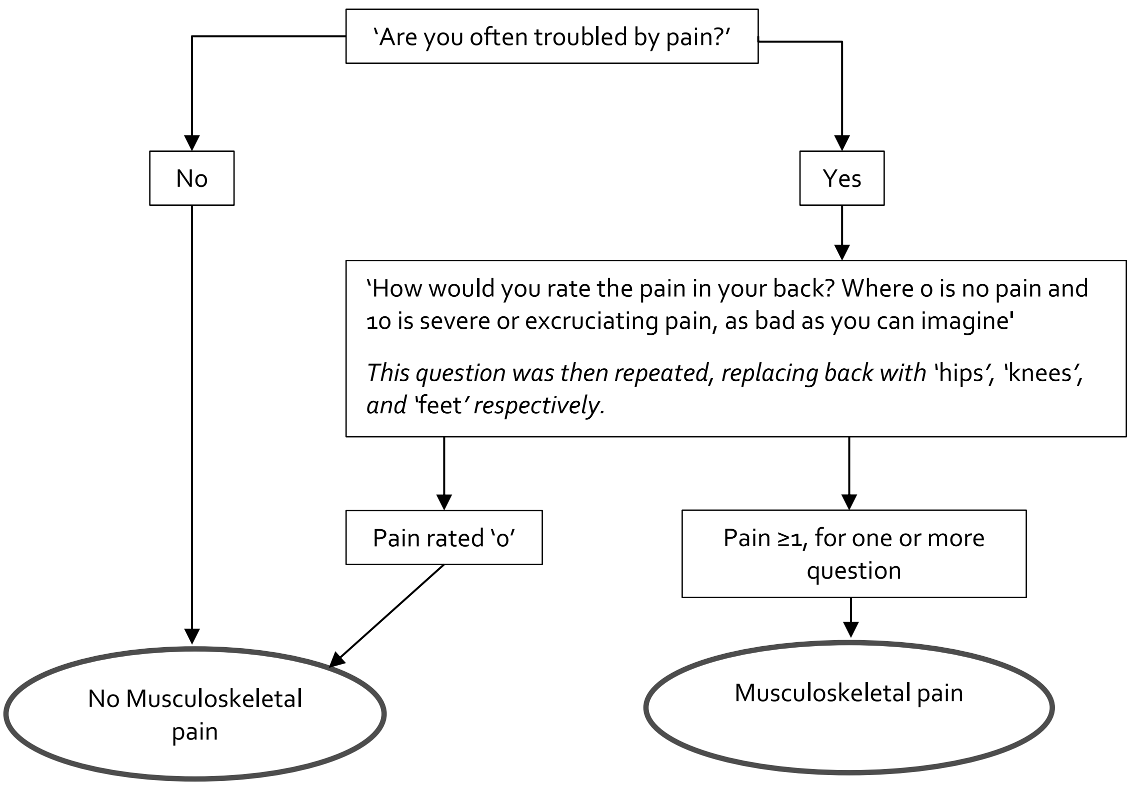


Figure 5:2 Flowchart showing how respondents were categorised for the musculoskeletal pain variable in those with no musculoskeletal pain and those with musculoskeletal pain

Overall the proportion of respondents at Wave 2 of ELSA (N=9292) reporting often being troubled by pain was 3506 (37.7%). There were 2944 of these (84.0%) who reported pain in their back, hips, knees or feet when walking on a flat surface (Table 5:2). The proportion with troublesome pain not categorised as musculoskeletal pain in this validation analysis (i.e. 16%) is therefore an estimate of potential misclassification if the 'are you often troubled with pain' question is used alone as a proxy for troublesome musculoskeletal pain. However, this is likely to overestimate likely misclassification since some of the 16% will include older people with troublesome musculoskeletal pain originating in upper limb and upper body areas not captured by individual body area questions in ELSA (e.g. shoulder, elbow and neck pain). A systematic review of the prevalence of musculoskeletal problems in the elderly population (older people aged 60 and over) in developed countries for example estimated the prevalence of shoulder pain to be 5%, hand/wrist pain 3%, and elbow pain 3% (Fejer and Ruhe, 2012).

Table 5:2 Crosstabulation showing number of ELSA respondents often troubled by pain by: i) the number reporting pain originating in the back, hips, knees and/or feet (musculoskeletal pain), and ii) the number reporting a diagnosis of arthritis

			Often troubled by pain?		Total
			No	Yes	
i) Musculoskeletal Pain	No	Count	5786	562	6348
		%	100.0%	16.0%	
	Yes	Count	0	2944	2944
		%	0.0%	84.0%	
	Total Count		*5786*	*3506*	*9292*
ii) Reports a diagnosis of arthritis?	No	Count	2653	742	3395
		%	78.1%	21.9%	
	Yes	Count	763	1068	1831
		%	41.7%	58.3%	
	Total Count		*3416*	*1810*	*5228*

A further comparison was made between those reporting being often troubled by pain and those who reported a diagnosis of arthritis (Table 5:2). For this comparison the answer to the 'arthritis diagnosis received' question was restricted to the responses recorded in waves 1 and 2 of ELSA so that the answers would represent the status at the time-point (i.e. Wave 2) when people were first asked about pain. Table 5.3 shows the responses cross-tabulated. Those reporting diagnosis at subsequent waves were considered not to have a diagnosis at this time point and those reporting don't know were excluded from analysis. As might be expected, this cross-tabulation shows less discord between arthritis self-report and pain self-report than observed for each separate joint site in the MSK Calculator analysis of ELSA data (Adomaviciute et al., 2015). This presumably is because the single question here combines a number of locations and is compared with a general question about diagnosed arthritis. Even so there is a clear disparity in responses to the two questions. Notably, more than 40% of those reporting 'musculoskeletal pain' could not recall their doctor diagnosing arthritis, whilst 41% of those recalling a diagnosis of arthritis did not report pain. There is an association between the two measures, but it is weak. This adds to the justifications given in the first section of 5.3.1 (above) for not using 'self-reported arthritis diagnosis' as the measure of musculoskeletal pain.

This analysis provides empirical evidence to support the use of the question 'Are you often troubled by pain?' as a suitable proxy for capturing musculoskeletal pain likely to be associated with subsequent mental and/or physical health in older people, and for enabling the role of social participation on this association to be examined in more detail.

5.3.2 MENTAL HEALTH

The measures of mental health available in ELSA included doctor-diagnosed psychiatric problems, with details of the age at time of diagnosis. The mental health problems asked about were: anxiety, depression, schizophrenia, hallucinations, emotional problems, mood swings, manic depression and psychosis. An additional response option was 'something else'. Initial exploration of the ELSA items relating to self-reported doctor-diagnosed psychiatric problems found that the response for 97.5% of ELSA Wave 2 respondents (9197 of the 9432 respondents) was categorised as 'not applicable'. In total, only 235 (2.5%) respondents reported one or more mental health problem, with two additional respondents answering 'don't know'. An additional ELSA item was available providing information on whether an individual had experienced any emotional, nervous or psychiatric problems within the last two years. Wave 2 response rate for this item was: yes 363 (3.8%), no 322 (3.4%) and not applicable 8747 (92.7%). Consequently, the use of doctor-diagnosed mental health problems was not considered any further due to the low number of events. Such low prevalence of events, would provide little discriminatory power in statistical models (Field, 2013), and furthermore was not likely to be representative of the estimated prevalence of poor mental health in older people. Clinically significant depressive symptoms, the most common mental health condition reported by older people (WHO, 2016), are estimated to be present in approximately 15% of community-dwelling older people (WHO, 2016;Blazer, 2003). In comparison, in Wave 2 of ELSA doctor-diagnosed depression was reported by 165 (1.7%) of respondents.

An alternate source of information on mental health provided in ELSA was the 8-item version of the Center for Epidemiologic Studies on Depression (CES-D 8) questionnaire.

The CES-D 8 has been widely used in studies of late life depression, and has good psychometric properties for use in older community dwelling populations. CES-D 8 asks about the occurrence of the following symptoms in the previous 1-week period, with response options of 'yes' or 'no':

1) I felt depressed

2) I felt everything I did was an effort

3) My sleep was restless

4) I was happy (reverse scored)

5) I felt lonely

6) I enjoyed life (reverse scored)

7) I felt sad

8) I could not "get going"

The total number of 'yes' responses to questions 1, 2, 3, 5, 7, 8, and the 'no' responses to questions 4 and 6 were summed to provide a total depressive symptom score ranging from 0 to 8. A cut point of four or more depressive symptoms (Hamer, et al., 2009) was used to distinguish those with poor mental health (coded 0) from those with good mental health (coded 1). Psychometric analyses of the 8 item CES-D indicate adequate psychometric properties to support its application to identify depressive symptoms within older adult population studies (Karim, et al., 2015; Missinne, et al., 2014). 9157 ELSA respondents provided valid responses to all CES-D 8 items, with a mean score of 3.1 (range 0-8) and a standard deviation of 1.4. Therefore CES-D 8 offered potentially better discriminatory power across the whole sample than did individual or summed doctor-diagnosed mental health problems.

While the objective of the CES-D 8 is to capture depressive symptomatology, depressive symptoms commonly co-occur with other symptoms of poor mental health in older people. A study of an elderly community sample found 12.2% reported symptoms of depression only, compared to 2.9% reporting only generalised anxiety, and 1.8% mixed anxiety-depression (Schoevers et al., 2003). Prevalence estimates of depression in older adults with anxiety disorders suggest 26.1% of those with anxiety disorders also meet the criteria for major depressive disorder, with this proportion being higher if milder depression is considered (Beekman et al., 2000).

The association between musculoskeletal pain and depression in cohorts of individuals with chronic pain is well documented (Asmundson & Katz, 2009; Bair et al., 2003). Bair and colleagues conducted a comprehensive literature review of qualitative and quantitative studies addressing both depression and pain symptoms. They found prevalences of pain in depressed cohorts, and of depression in pain cohorts, to be higher than those expected in a general population sample. The average prevalence of major depression across 10 primary care or population-based studies of individuals with pain was 27% (ranging from 5.9% to 46%). The mean prevalence was even higher for studies in pain clinic settings (52%, range:1.5-100%) and orthopaedic clinics or rheumatology clinics (56% (range:21-89%), although the variation in estimates was wide in range and the number of patients in the clinic-based studies very low (i.e. 13 of the 18 studies had ≤80 participants). Bair and colleagues (2003) found increasing frequency and/or severity of pain, and of widespread pain, to all be more strongly associated with co-existing depression than reporting no pain or occasional pain. Reviews focussed specifically on older populations (i.e. individuals aged

≥65 years) have also found musculoskeletal or persistent pain to be associated with increased risk of depression when examined only in older populations (Molton & Terrill, 2014). However, it does not appear that all older people with musculoskeletal pain experience depressive symptoms. A Swedish population based study (Larsson et al., 2017) of 2415 individuals ≥65 years old found that, when grouped according to pain and mental health characteristics as well as pain catastrophizing, four distinct groups emerged. Approximately 15% of the sample had moderate pain severity and high levels of depression and anxiety, and a further 22% had high pain severity and moderately high levels of depression and anxiety. These two groups were significantly associated with higher health care costs, compared to a referent group consisting of older individuals with low pain severity and low levels of anxiety and depression.

EMPIRICALLY TESTING THE ASSUMPTION THAT DEPRESSIVE SYMPTOMS ARE A PROXY FOR MENTAL HEALTH IN ELSA

To empirically test the assumption that CES-D scores provided a suitable proxy measure of mental health an independent t-test was used to test the assumption that the mean CES-D score would differ significantly between those reporting a doctor-diagnosed psychiatric problem in the last two years and those who did not. There was a significant difference in the CES-D scores, with those reporting a psychiatric problem within the last two years scoring a mean of 4.2 (standard deviation=1.7), and those who did not report a doctor diagnosed psychiatric problem scoring a mean of 3.1 (SD=1.3); $t(651)=9.1$, $p =<.001$. As described later in the thesis, for the purpose of empirical analyses in this thesis, a cut point of four or more depressive symptoms was used to create a dichotomous variable from the CES-D scores. This is consistent with the methods of previous epidemiological research (Hamer, et al., 2009), with a score of 3 or less interpreted as indicating good mental health. To further test the assumption that CES-D 8 provided a suitable proxy measure for mental health, mean CES-D 8 scores of those respondents reporting a doctor-diagnosed mental health problem were examined separately for each diagnosed problem and compared with scores for respondents without any diagnosed mental health problem (not restricted to the last two years). A total of 9157 respondents provided the necessary data to be included in analyses. When grouped by condition, the mean CES-D 8 score was >3 for each condition examined (Table 5:3).

Table 5:3 Table showing the number of respondents (N=9157) reporting each condition and the mean CES-D 8 score for that group of respondents

	Number of respondents with condition	Mean CES-D score
Hallucinations	5	4.2
Anxiety	134	3.9
Depression	153	4.1
Emotional problems	47	4.1
Psychosis	11	5.5
Mood swings	32	4.3
Manic depression	2	5.0
Something else	18	3.6
Schizophrenia	0	N/A
Comparison group: none of the above conditions reported	8936	3.1

When interpreting the information in Table 5:3 it is important to consider that the CES-D 8 questions asked the respondent how they have felt during the last two-weeks, while reports of doctor-diagnosed psychiatric conditions could relate to any previous point in time. Consequently, it would be expected that symptoms had resolved, or improved with management, for some respondents who reported one or more doctor-diagnosed psychiatric problem. This would result in a lower CES-D 8 score than would be expected if only those with active symptoms were included. Approximately one in three adults with mental health conditions do not seek treatment from their GPs or other healthcare providers about concerns over mental health (NHS digital, 2016). Consequently, it can be expected that a proportion of those experiencing poor mental health did not consult their GP, thereby not receiving a diagnosis. This would lead to them being erroneously allocated to the comparison group, artificially inflating the CES-D 8 score for those categorised as without any mental health conditions. Consequently, whilst the difference in CES-D 8 score differed significantly between those with and without psychiatric problems, it is likely the true difference in CES-D 8 score would be greater than that identified in these analyses. In summary, CES-D 8 scores were selected as the measure for mental health as the CES-D 8 is validated for use in health surveys, demonstrated appropriate correlation with reports of doctor-diagnosed psychiatric problems, and represented mental health at the time of the survey, rather than across the life-course more generally.

5.3.3 PHYSICAL HEALTH

This section describes in more detail why physical health was defined using self-reported health status. A systematic approach was taken to screening the ELSA dataset and selecting the best outcome measure available to represent physical health. The following criteria were set as essential:

1) The outcome must capture one or more aspects of physical health and be conceptually distinctive to, and measured independently from, social participation and musculoskeletal pain

2) Empirical evidence must be available to support the hypothesis of a *causal* association existing between musculoskeletal pain and the outcome (i.e. pain is not a primary symptom of the outcome) as this is essential for effect mediation

3) A valid measure of the outcome must be available at each wave of ELSA from baseline to four-year follow-up

4) 10% or more of the 7266 participants assigned to a social participation group at baseline must report a change in outcome status between baseline and four-year follow-up (as the premis of effect mediation is that it seeks to explain change in an outcome in response to change through a third, mediating variable.)

Of the 20 ELSA items capturing one or more aspect of physical health that were extracted from ELSA, only self-rated health remained once the screening criteria were systematically applied. Self-rated health is how a person rates their health when asked, and answers in an evaluative and comparative nature (Latham & Peek, 2013). The measure of self-rated health used in ELSA was a single question 'Would you say your health is; excellent, very good, good, fair, or poor?', and was conceptually distinct from social participation and musculoskeletal pain. The measure was also included in each wave of ELSA. The reasons for exclusion of the other 19 ELSA items are provided in Figure 5:3.

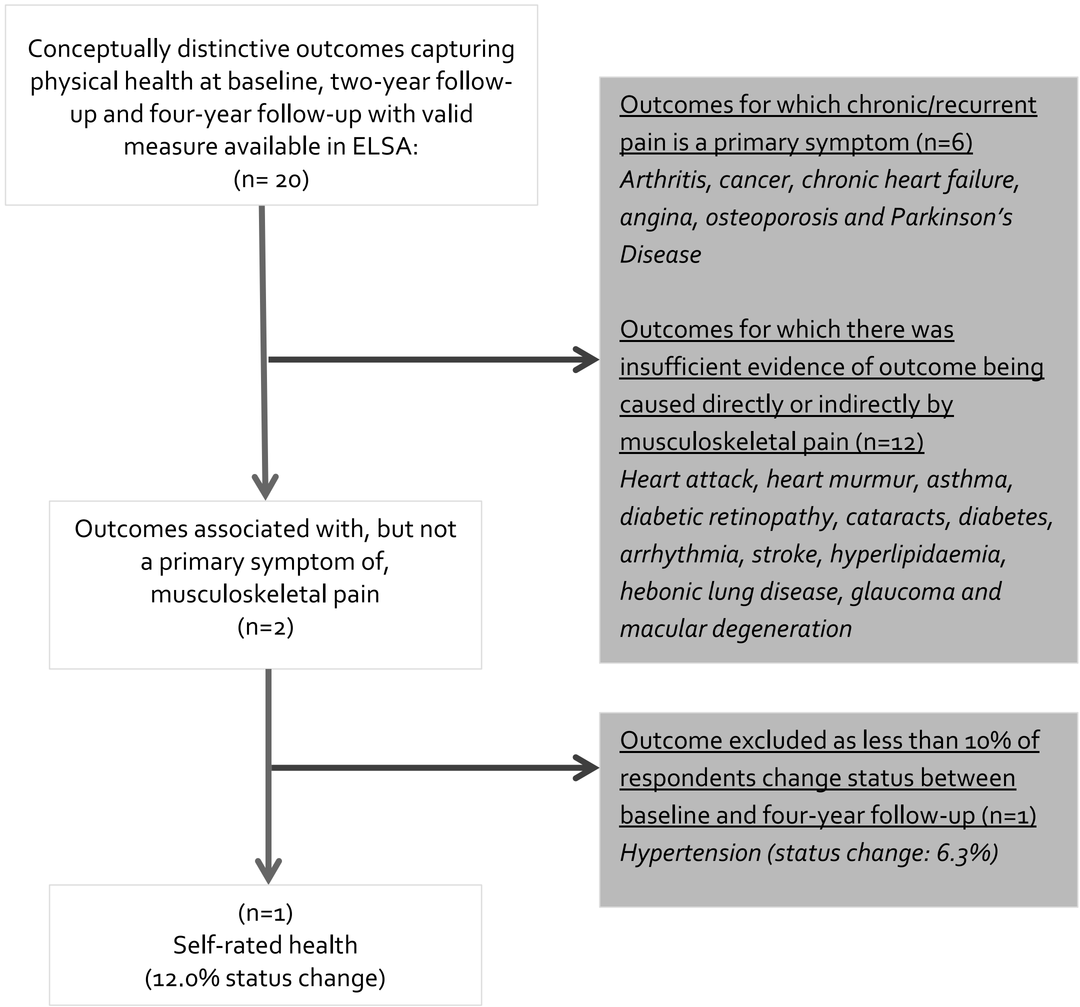


Figure 5:3 Selection of a measure of physical health

Self-rated health is a valid measure of health status in older people, including ethnic minority groups (Chandola & Jenkinson, 2000), and has good test–retest reliability (Lundberg & Manderbacka, 1996). A meta-analysis of 163 studies published between 1966 and 2003 found self-rated health to be a strong and reliable predictor of physical health, being linked to increased healthcare utilisation and diagnosed mortalities in the general population (DeSalvo et al., 2006). Self-rated health not only captures current physical health status, but is also a prognostic factor for subsequent physical health. Poor self-rated health has been linked to increased risk of cardiovascular mortality in those both with and without existing cardiovascular disease (Mavaddat et al., 2016;Waller et al., 2015), and the effect appears to be independent of other known cardiovascular risk factors, with the exception of diabetes (Waller at al 2015). Multivariable models have shown the association between self-rated health and physical health to persist independently of mental health status (Borim et al., 2014). However, studies of older populations have found depressive symptoms are strongly correlated with self-rating one's own health as poor (Millán-Calenti et al., 2012; Cucciare et al., 2010). In this study, mental health at baseline was included in the analysis to adjust for putative confounding of the musculoskeletal pain-physical health relationship by depressive symptoms.

There is evidence that musculoskeletal pain increases the risk of subsequent poor self-rated health in older people. A small, longitudinal study found that older people (aged >75 years) with non-cancer chronic musculoskeletal pain were twice as likely to report poor self-rated health (Karttunen, et al., 2015), although the study had a small sample size (n=256) and the wide 95% confidence interval for the effect suggests results varied widely between cases. However, these findings corroborate those of larger studies, including a study of 4542 adults which found that chronic pain occurring more than twice a week doubled the risk of poor self-rated health compared to the risk associated with reporting no pain (Mäntyselkä, et al., 2003), and for those with daily pain the odds were over 11 times higher than those with no pain. These findings included adjustment of likely putative factors including low mood and receipt of treatment for chronic disease(s). A Canadian health survey study, n=9371, also found pain to be associated with double the odds of reporting poor self-rated health after adjusting for socioeconomic confounders and other health factors, although this dropped to odds of 1.5 when examined only in those aged 55 years or more (Shooshtari, et al., 2007). The Canadian study also looked at predictors of good self-rated health in those ages 55 years or more and found pain to be associated with half the odds of reporting good self-rated health compared to no pain in the fully adjusted model (Shooshtari, et al., 2007).

Self-rated health was measured in ELSA by the following question: 'Would you say your health is: excellent, very good, good, fair, or poor?'. For the purpose of this thesis, the responses were categorised into a binary measure as follows: (1) excellent/very good/good or (0) fair/poor (Emerson et al., 2014). Self-rated health measured using a single question asking respondents to rate their health has been shown to be a better predictor of healthcare utilisation and mortality than other more complex self-rated health measurement instruments (DeSalvo, et al., 2005), making it a meaningful outcome for primary care. While it is appreciated that self-rated health is also known to capture mental health, this will be addressed in the analyses by adjusting for mental health status as a confounding factor. If the analyses in this thesis were not constrained by available information captured in ELSA, but were performed on purposely collected data, then an alternate measure of physical health could have been selected, e.g. the SF-36 physical component summary score (Ware & Sherbourne, 1992).

EMPIRICALLY TESTING THE ASSUMPTION THAT SELF-RATED HEALTH IS A PROXY FOR PHYSICAL HEALTH IN ELSA

To empirically test the assumption that an individual's self-rated health was an appropriate proxy measure of physical health self-rated health, responses in ELSA were examined against reports of doctor-diagnosed physical health conditions using crosstabulation. A morbidity composite variable was used, derived from multiple individual ELSA items. The variable captured multiple doctor-diagnosed physical health conditions available in the ELSA dataset: angina, myocardial infarction, congestive heart failure, heart murmur, arrhythmia, diabetes and stroke, lung disease, asthma, arthritis, osteoporosis, cancer and Parkinson's disease. A categorical variable was created, with respondents categorised as either reporting i) none of the conditions, ii) one condition, iii) two conditions, or iv) three or more conditions. The optical health conditions asked about in ELSA (glaucoma, diabetic eye disease, macular degeneration and cataracts), and conditions associated primarily with mental health (psychiatric disorders, Alzheimer's disease and dementia or memory problem) were excluded from the physical health morbidity measure.

Of the 9291 respondents, 6709 (72.2%) rated their health as good, very good or excellent, while the remaining 2582 rated their health as fair or poor. Cross-tabulation was used to examine the number of physical health conditions reported by those with good/very good/excellent self-rated health, compared to the number reported by those with fair/poor self-rated health (Table 5:4). A trend was seen, with the proportion of respondents rating their health as good/very good/excellent being 90.3% for those with no physical health condition, reducing to 33.9% of those with three or more conditions. Of the 2582 individuals who rated their health as fair or poor, 87.2% (n=2257) reported one or more physical health condition.

Table 5:4 Crosstabulation showing number of doctor-diagnosed physical health condition* by self-rated health for Wave 2 ELSA respondents

			Self-rated health		Total
			poor/fair	good/very good / excellent	
Number of physical health conditions diagnosed by a doctor	None	Count	325	3028	3353
		%	9.7%	90.3%	
	One	Count	771	2340	3111
		%	24.8%	75.2%	
	Two	Count	690	933	1623
		%	42.5%	57.5%	
	Three or more	Count	796	408	1204
		%	66.1%	33.9%	
	Total respondents		2582	6710	9291

* conditions include: angina, myocardial infarction, congestive heart failure, heart murmur, arrhythmia, diabetes, stroke, lung disease, asthma, arthritis, osteoporosis, cancer and Parkinson's disease

To test the assumption that self-rated health captured information on physical health, rather than reflecting a respondent's mental health, crosstabulation was used to examine self-rated health responses to mental health. 7026 respondents provided complete data, of these 5183 (73.4%) rated their health as 'good' or better. Of those with good self-rated health, approximately one in five (22.5%) reported poor mental health. Similarly of the 1843 individuals rating their health as 'poor' or worse, 838 (45.5%) reported good mental health. The likelihood of an individual in this population reporting both poor mental health and poor self-rated by a chance overlap (reflecting the prevalence of each construct) is (30.2%*26.2%) = 7.9%. The observed overlap in the individuals providing complete data is (1005/7026) = 14.3%, which is approximately double that expected if the two constructs were independent of each other. This suggests there is an association between these two measures. However, while 42.1% (2957) of the individuals have either poor mental health or poor physical health, or both, 1952 (66.0%) do not have both poor mental health and poor physical health. It is reasonable to conclude therefore that, in epidemiological terms, self-rated health is measuring a different dimension of health than mental health alone.

Table 5:5 Crosstabulation showing mental health by self-rated health for Wave 2 ELSA respondents

			Self-rated health		Total
			Good	Poor	
Mental health (CESD)	Good	Count	4069	838	4907 69.8%
	Poor	Count	1114	1005	2119 30.2%
		Total count proportion	5183 73.4%	1843 26.2%	7026 100%

Based upon the physical health conditions captured in ELSA, it seems that self-rated health is closely associated with physical health. As the number of physical health conditions increases, the probability of reporting good/very good/excellent health decreases. Furthermore, when mental health (using CESD 8) was compared to physical health using crosstabs, mental health and physical health demonstrated reasonable variation. Self-rated health thus seems to be a suitable proxy measure for physical health, and to be distinctive from the measure of mental health.

5.4 COVARIATES USED IN EMPIRICAL ANALYSES

5.4.1 SELECTION OF COVARIATES FROM ELSA FOR EMPIRICAL ANALYSES

The theoretical model illustrating the role of social participation in determining good health in older people with musculoskeletal pain (Figure 2:4, Chapter Two) was used to inform the statistical models tested in later empirical analyses. The choice of covariates capturing putative confounders (i.e. personal factors and environment) was also influenced by the availability of information in the ELSA cohort surveys. As ELSA was purposely developed for examining questions related to health, ageing, economic position and resources and social factors (Steptoe et al., 2012), and developed by a collaborating team of researchers (Steptoe et al., 2012), much of the data was collected using validated instruments. As discussed previously, for a variable to confound a relationship it must be unevenly distributed across groups. Therefore, a variable was not included in statistical models if there were low levels of variation across the sample (e.g. for ethnicity >95% of the sample was white). DAG theory was used to identify the most parsimonious model that accounted for the necessary putative confounders in pathway analyses. Specifically, any variables which were 'colliders', meaning a variable which is the outcome of two or more variables in a DAG, were not controlled for, as to do so actually introduces bias (Pearl, 2000).

Some variables were not included as they were conceptually captured by other composite variables or were found to have high collinearity to another variable in the model. For example, employment was one component captured in the multidimensional, composite variable measuring social participation, and economic adversity captured information relating to social class. Similarly, physical disability was not included as it was closely correlated with chronic limiting illness and conceptually any physical disability arising from a chronic health condition would be captured by the chronic limiting illness question. Additionally, physical activity levels, social support and a sense of purpose were all hypothesised as being downstream of social participation on the pathway to good health.

Consequently, these variables were only included in models testing for effect mediation, which sought to decompose any effect of social participation into that attributable to these downstream factors. Whereas, in the confounding and effect moderation models, inclusion of these variables would have been erroneous due to them capturing distinctive components of social participation (Hayes, 2013).

5.4.2 COVARIATE MEASURES

The covariates selected for the empirical models were chosen so as to enable known confounders of the association between musculoskeletal pain and social participation, and social participation and good health to be adjusted for. The selection was informed by the literature, and constrained by the availability of data in the ELSA dataset. Participant age was computed from date of birth (self-reported during the interview, or, if not recorded, obtained from the sampling database) and the date of interview. Participants were categorized into three groups (Mosier et al., 2010): pre-retired (aged 50-64 years), retired (aged 65-79 years), and oldest-old (80 years or more). These cut-offs were selected based upon the concept of 'social ageing'. Social ageing models propose that different life stages are associated with different cultural age-expectations of how people should act as they grow older (Phillips et al., 2010). Therefore, propensity for engagement in specific social activities may be hypothesised to be stronger in one age group than another as a result of cultural and societal norms. Categorising age in this way allowed the distribution of these age groups across social participation groups to be explored.

Self-reported gender was categorised as 'male' or 'female'. Socioeconomic status was operationalised using data on responder's total net non-pension wealth (Demakakos et al., 2008). Wealth has been shown to best capture the material resources available to older adults (Banks et al., 2003) and reflects both past and current socioeconomic status. The derived variable estimated wealth (NatCen, 2014) using detailed information about the value of all financial assets at the disposition of the benefit unit (i.e. houses, businesses, any other physical assets and all forms of savings and investments), excluding debts owed by the benefit unit (benefit unit is either a couple or a single person with any dependent children they may have). The wealth variable was divided into quintiles and dichotomised to identify the lowest 20%, who were categorised as living in economic adversity and compared to the remaining 80% (Montgomery et al., 2007). Ethnicity data was not included as a covariate in the analyses because less than 2.5% of the sample was non-Caucasian.

To ensure any other morbidity which negatively impacted upon an individual was considered, an additional measure of 'limiting, chronic illness' was also included. This measure of longstanding limiting illness has been shown to be a useful health indicator in epidemiological studies examining health in older people (Steptoe et al., 2013;Netuveli et al., 2006). Participants were asked about the presence of any long-standing illness, disability or infirmity that had troubled them over a period of time, and if identified as having a chronic illness they were then asked if these illnesses limited their daily activities. Responses were combined to form a dichotomous variable, indicating whether participants suffered from any limiting long-standing illness which limited their activities in some way, or not. Physical disability was considered, but not adjusted for as a confounding variable as it was too strongly correlated conceptually and statistically with limiting physical illness. Adjustment of multiple variables capturing similar constructs or which are highly collinear leads to over-adjustment, which may introduce bias or decrease precision of study findings (Pearl, 2000).

5.5 CHAPTER SUMMARY

The empirical analyses reported in this thesis use information collected from a cohort of English older people participating in the ELSA study. The baseline information used in this thesis was drawn from Wave 2 of the ELSA study, with follow-up information drawn from the two subsequent 2-yearly surveys. As secondary analyses are performed in this thesis, the data available for use is constrained to that collected as part of the ELSA survey. Consequently, proxy measures were used to capture the exposure of interest, musculoskeletal pain, and the outcomes of interest, mental and physical health respectively. The ELSA items providing the information and the reasons for the choices made have been presented. Descriptive analyses performed to test the assumptions made about proxy measures demonstrated the choices to be fit for purpose.

CHAPTER SIX: IDENTIFYING DISTINCTIVE SOCIAL PARTICIPATION GROUPS IN OLDER PEOPLE

6.1 CHAPTER OVERVIEW

This chapter addresses Objective 3 of the thesis; to identify groups of older people who share similar social participation characteristics, which could then be used in subsequent analyses to examine the role of social participation in older people with musculoskeletal pain. To achieve this objective distinctive social participation groups were identified using a latent class analysis (LCA) of data drawn from Wave 2 of ELSA. This chapter starts with an introduction to the theory underpinning LCA, and then presents the LCA study used to identify distinctive social participation groups in this thesis.

6.1.1 MEASUREMENT OF SOCIAL PARTICIPATION IN OLDER PEOPLE

MEASURING SOCIAL PARTICIPATION IN ELSA

A validated, multi-dimensional measure of social participation was not included in the ELSA data, therefore an objective of this thesis was to find a way to identify groups of participants who shared distinctive social participation profiles, based on their reported social participation activities and in line with the Levasseur model of social participation. ELSA captures various indicators of social participation (Jivraj et al., 2012;Steptoe et al., 2012). In the ELSA technical report independent questions on care-giving, social network and the use of public transport are included in the social participation domain (Cheshire et al., 2012). In addition, items that measure social participation activities matching the model of social participation devised by Levasseur and colleagues (2010) can be found in other domains. Previous studies concerned with measuring social participation in ELSA have mainly measured social participation as a simple count score summed from relevant data items (e.g. Steptoe et al., 2013; Kouvonen et al., 2012;Netuveli et al., 2006). However, scores devised via this method are driven by the number of different activities, rather than identifying multidimensional profiles of the combinations of activities performed. Another method is to create variables categorising individuals according to the frequency of participation in voluntary work and organisations (e.g. Rouxel et al., 2015). This method provides only a one dimensional view of what social participation activities older people engage with, therefore also failing to provide an insight into the multidimensional combination of activities and social roles which constitute social participation. While such methods provide a useful way to discriminate between individuals in terms of social participation, they provide only vague notions of what such activities may be. Summative scales of social participation have also been critiqued for combining conceptually distinct activities into a single scale (Hong et al., 2009).

A search for articles reporting approaches to classify older people according to their multi-dimensional patterns of social participation activities identified two articles (Croezen et al., 2009 and Hong et al., 2009). Croezen and colleagues (2009) used cross-sectional data collected from 22026 independently living adults aged ≥65 years registered with Dutch community health services. Principal component analysis reduced data on 17 social participation activities into 6 distinctive types of activity: voluntary, physical, visiting, hobby, work and care (Croezen et al., 2009;p777). Then cluster analysis was used to identify groups of older adults; identifying a 5 cluster model as the best fitting. Some of the included activities (e.g. cycling, using internet and walking) would not fulfil the definition of social participation applied in this thesis, but rather characterised the broader concept of participation (Levasseur et al., 2010). Hong and colleagues (2009) used latent class analysis (LCA) to analyse information on 8 social activities (working, volunteering, attending religious services, exercising regularly, getting together with others (e.g. family, friends, and neighbours), talking on the telephone with others, going to movies or sports events, and eating out) collected from a sample of 5294 community dwelling older people. They identified a 3 class model (which differed in terms of the frequency of social participation activities) as being the best fitting, with significant differences in demographics and health being found between groups.

6.1.2 SELECTION OF A METHOD TO GROUP PARTICIPANTS BY SOCIAL PARTICIPATION CHARACTERISTICS

A latent variable is a variable which indirectly measures construct, which is not itself observed, using other observable variables (Masyn, 2013). Creating a latent variable was selected as the most suitable approach to classify older people according to their observed patterns of social participation activities using the wide range of items available in ELSA. Clustering techniques are the most appropriate methods by which to identify the structure of a latent variable from a collection of observations (Woods, 2013; Collins & Lanza, 2010). Rather than starting with a priori categorical structures and fitting them to data, these techniques allow the analyst to identify naturally occurring groupings within the data set. Three clustering techniques were identified as potentially suitable methods for modelling a latent social participation outcome from observed variables; factor analysis, cluster analysis and latent class analysis.

Factor analysis (of which principal component analysis is a variation) is a well-established method of reducing multiple, observed variables into one or more underlying latent factors, however it is used for continuous and usually normally distributed latent variables rather than discrete variables (Brown, 2013). As the desired outcome for categorising older people into groups was a categorical variable capturing information regarding the type of social participation activities performed, rather than a scalar measure of social participation extent for example, factor analysis was regarded as unsuitable. Furthermore, factor analysis is a variable-centred data reduction method, in that it describes associations among variables, and makes predictions based on the assumption that any associations between variables are homogenous across all cases within the population (Masyn, 2013;Brown, 2013). Factor analysis therefore would not offer a way of differentiating between participants per se, but rather a method of expressing social participation characteristics captured by observed variables more parsimoniously using one or more latent factor(s) generalised across a population. This analysis required a case-centred reduction method, whereby smaller groups of similar cases that are representative of the whole dataset are identified from the total number of cases in a dataset.

Traditional cluster analysis and LCA are case-centred, data reduction methods. Unlike variable reduction methods which reduce the number of variables by forming factors, cluster analysis and LCA instead reduce the number of cases by forming groups of cases providing similar responses to several variables (Masyn, 2013). The aim of such methods is to generate groups of cases according to similarities and differences in terms of associations between indicator variables, with bigger differences observed between groups then within groups (Masyn, 2013). Various approaches to cluster analysis exist, although all share the common goal of grouping a set of cases in such a way that cases within a group (cluster) are more similar (in terms of observed variable characteristics) to each other than to those in other groups (Field, 2000). Traditional cluster analysis starts by considering each case as a separate cluster then progressively merges clusters with close 'geometric proximity', which is a measure of similarity between reciprocal variable data for two cases (Field, 2000). Traditional cluster analysis thus represents a bottom up approach to data reduction, combining cases with others which are similar until no more matches can be identified.

The fundamental objective of LCA is the same as that of traditional cluster analysis methods. However, the approach LCA takes to deriving clusters differs to the methods of traditional cluster analysis techniques. Like traditional cluster analysis LCA aims to group similar cases within large and heterogeneous populations (Collins & Lanza, 2010). However, LCA uses a probabilistic model to describe the distribution of the observed data in a (pre-specified) number of subgroups, rather than in terms of geometric distance between case measurements as in traditional cluster analysis (Masyn, 2013). This means that rather than being solely allocated to a single group, as in cluster analysis, each case has a probability of membership in each of the latent classes. These probabilities arising from the model indicate the confidence of correct allocation (i.e. probabilities range from 0-1, with 1 indicating total certainty and increasing uncertainty demonstrated as values deviate away from 1.) Retrospectively the known distribution of indicators within a group can be used to predict a cases group affiliation using posterior probabilities (Masyn, 2013).

6.1.3 INTRODUCTION TO LATENT CLASS ANALYSIS

LCA is a multivariable method and a type of finite mixture modelling which uses a finite number of observed 'indicator' variables, capturing one or more aspect of the latent concept, to model a categorical latent variable with a pre-specified number of groups (Masyn, 2013). As with other finite mixture models LCA expresses the overall distribution of the observed indicator variables as a mixture of the finite number of component distributions (Masyn, 2013). Indicators are usually discrete, and the number of groups (*j*) is imposed by the researcher as part of the model specification (Huang & Bandeen-Roche, 2004). In a well-fitted LCA model the generated latent variable(s) produces groups of cases which have strong within-group similarity, and demonstrate discernible between-group differences. LCA is data driven, with the researcher specifying the number of classes and indicator variables which contribute to the LCA model, but the defining characteristics of the groups arise directly from the distributions observed in the data.

LCA uses a probabilistic model which enables additional output, beyond allocation of group membership, to be provided. Statistically generated goodness-of-fit indices are available to compare between models and group membership probabilities better capture uncertainty in group classification (Masyn, 2013). This additional information is not available for traditional cluster analysis. Having statistically based criteria to inform the selection and interpretation of the most appropriate number of groups was important within the context of this analysis as there were no a priori hypothesis of the expected number of SP groups. Therefore, the ability to compare across models with different number of latent groups enabled the latent variable which best explained the observed variation in the sample of older people. Another advantage of using LCA in this study is that, unlike traditional cluster analysis, LCA does not require a decision to be made on whether to standardize the items capturing social participation in some way, so that they all contribute equally to the geometric distance between cases, or to have some contributing more than others.

MODEL SPECIFICATION: LATENT CLASS ANALYSIS MEASUREMENT MODEL

LCA modelling consists of two components; a measurement model which relates the observed indicator variables to the underlying latent variable(s), and a structural model which characterises the distribution of the latent variable(s) and their association with other latent and observed variables (Masyn, 2013). The measurement model can be applied to alternate datasets to perform confirmatory, between-group analyses. The measurement model specifications also enable a structurally equivalent latent variable to be modelled longitudinally across data waves using model constraints. This attribute was appealing in the context of this analysis as it would enable social participation group membership to be examined across subsequent waves using a consistent variable structure to that derived at baseline. The function for predicting class membership from observed binary indicators in a basic LCA measurement model is given in Equation 5:1[7].

$$f(x_i) = \sum_{c=1}^{C} n_c \prod_{j=1}^{J} \pi_{jc}^{x_{ij}} (1 - \pi_{jc})^{1-x_{ij}} \qquad (Eq.5.1)$$

Equation 5:1 Basic LCA measurement model with binary indicator variables

[7] C represents groups or classes ($c = 1, \dots, C$) and J the observed indicator variables ($j = 1, \dots, J$). n_c is the probability that an individual case 'i' is a member of a given class c. x_{ij} is the observed response of case i to item j. π_{jc} is the probability of a positive response to item j from an individual in a known class, c. $\sum n_c$, the sum of class membership probabilities, must sum to one as membership in one of the possible classes is a certainty.

The equation draws upon the Bernoulli distribution function, a simple distribution for independent single events with binary outcomes (Bartholomew & Knott, 1999). The Bernoulli distribution is a discrete distribution having two possible outcomes labelled by n=0 and n=1 in which n=1 (success) occurs with probability p and n=0 (failure) occurs with probability $q=1-p$, where $0<p<1$. The distribution allows the probability of a positive response to item (j) from an individual in a known group (c) to be modelled, providing each case with a probability of belonging in each of the possible groups. Individuals are allocated, based upon their group membership probabilities, to the group for which they have the highest membership probability (Masyn, 2013). This differs from the method used by traditional clustering techniques whereby the process of successively combining similar clusters means individual cases can belong only to a single cluster at any point in the analyses.

LATENT CLASS ANALYSIS MODELLING ASSUMPTIONS

LCA is a non-parametric technique, so does not require any assumptions related to linearity, normal distribution or homogeneity to be met (Masyn, 2013). Observed indicator variables should be categorical or ordinal level data, with latent profile analysis available for those wishing to model continuous indicators (Muthén & Muthén, 2015). The LCA model assumes that the unobserved (latent) groups of the generated categorical variable explain any associations between the indicator variables, known as conditional independence (Masyn, 2013). The LCA model estimates parameters based upon the assumption that the latent class is the reason for any correlation between indicator variables, so it is assumed that once group membership is accounted for the indicator variables should become uncorrelated (Hagenaars, 1988).

If not accounted for, violations of conditional independence influence the model fit indices, inflating the number of groups required in order to fit the data (Hagenaars, 1988) and yielding spurious and often theoretically uninterpretable findings. Even if the correct number of latent groups is known a priori, a model lacking conditional independence will result in biased estimates (Vacek, 1985). Furthermore, increasing the number of latent classes always improves the key assumption of local independence in LCA (Suppes & Zanotti, 1981). However, resulting classes, although derived from an empirically superior model based on model fit statistics, may be difficult to interpret, and a substantively more meaningful model with potential model misspecification may be considered a more pragmatic choice (Reboussin et al., 2008). Additionally, clearly defining the underlying theoretical model, and ensuring robust theoretical justification for chosen indicators capturing the proposed latent construct, is important and may help minimise unnecessary problems with dependence which might occur from indiscriminative inclusion of variables. Other, more complex approaches which may be considered if local independence assumptions are not met are the inclusion of covariates and/or use of hierarchical latent class models (Clark & Bengt, 2009). However, these methods were not performed within this research project and further discussion is outside the scope of this thesis.

POWER IN LATENT CLASS ANALYSIS

The number of cases needed for LCA modelling varies. It is generally recommended that 10-20 cases are required for each indicator variable to provide sufficient power to a model (Collins & Lanza, 2010), but no definitive guidelines exist. Furthermore, power analysis in LCA models is not straightforward as, in addition to the usual factors (e.g. level of significance, effect size and sample size etc.), design factors which are exclusive to LCA must be considered. These include class proportions, the number of classes, and the number of possible indicator endorsement patterns which have a cell count greater than zero (Tekle et al., 2016). Sparseness, where not all possible indicator endorsement pattern combinations are observed, can result in some or many cell counts being zero. In this case the actual information available from observed data may be less than expected and can negatively impact upon model identification (Masyn, 2013). The inclusion of indicators with poor discriminatory power (e.g. >95% endorsement for a single response) is not recommended, although again no definitive cut-off for binary indicator endorsement is available.

STRUCTURAL MODEL TESTING

Traditionally the components of an LCA are run as two distinct consecutive stages, with the unconditional measurement model being established before proceeding with any structural model based hypothesis testing (Masyn 2013;Huang & Bandeen-Roche, 2004). Structural models may be used to test if the number of classes is the same across data groups in a technique called measurement invariance testing (Collins & Lanza, 2010). In measurement invariance testing an identified measurement model is applied to a different set of data. The first step is to fit an unconstrained model, then parameters are restricted to those of the pre-identified structural model and the models evaluated in terms of model fit. Measurement invariance is established when the group-specific conditional indicator response probabilities are equal across different data (Kankaras et al., 2011), indicating that the measurement model has equivalent fit to both data. Poor fit of the constrained model to the second data suggests structural heterogeneity between the underlying latent variables of the two sets of data. Measurement invariance is an important tool when testing whether differences between groups or time points may actually be due to the measurement instrument and not to the construct in question (van de Schoot et al., 2012).

6.1.4 LATENT CLASS MODEL ESTIMATION

The process of LCA modelling starts with estimating a model with a single, one-class latent variable. Model output relating to fit and diagnostics are then used to determine if the one-class model is a good fit. If a one class model fits the data well, it suggests that there is no relationship between the indicator variables that requires explanation, and so modelling an underlying latent variable is inappropriate (Collins & Lanza, 2010). If appropriate, subsequent models are run with the number of groups in the latent variable increased by one in each step. At each step the researcher should check that model estimation terminated normally (the model was identified), and the best loglikelihood values have been replicated (indicating a global solution was found). Failure to do so may result in inappropriate findings being reported.

MODEL CONVERGENCE

LCA uses maximum likelihood (ML) estimation (Goodman, 1974), or variations such as ML with robust standard errors, to identify the best fitting solution of the model to the data (Collins & Lanza, 2010). These iterative estimation methods involve repeated attempts to obtain estimates of parameters. This iterative process is continued until no new set of estimates can be found which provide improved model fit compared to the previous set of estimates, at which point the model is said to have converged (Collins & Lanza, 2010).

Non- convergence occurs when consistency in parameter estimates is not achieved, and can indicate either a problem in the data, a mis-specified model or both (Collins & Lanza, 2010). Local solutions arise when estimated parameters are consistent between iterative cycles but do not represent the best possible set of parameter estimations; the latter is known as a global solution. There is no way to determine with certainty that a global solution has been identified, however to maximise the chance of identifying a global solution (rather than a local solution) multiple random start values may be used (Blunch, 2008).

MODEL IDENTIFICATION

A statistical model is said to have been 'identified' if there is sufficient known information available to establish one best value for each parameter to be estimated in the model exists (Hershberger, 2006). A model may also be under-identified, just-identified, or over-identified. A model which is just-identified will have zero degrees of freedom and one, unique set of parameter solutions. In an under-identified model there are one or more unknown parameters with multiple possible solutions, and in this case the degrees of freedom will be negative (Hershberger, 2006).

Over-identification is the most desirable model status, where the number of known data elements in the model as a whole is more than the number required to identify a unique solution. Over-identification means that, for at least one parameter, there is more than one equation the estimate must satisfy; only in this scenario is there opportunity for the model to be rejected by the data (Hershberger, 2006). If a model is not identified, it must be re-specified by increasing the number of observed variables or by reducing the number of parameters to be estimated so as to make it so (Blunch, 2008;p.78).

MODEL FIT

There is no gold-standard method for determining the optimal number of classes in a LCA (Collins & Lanza, 2010). In most research the true model, i.e. the one representing the actual situation which yielded the observed data, is not known. Therefore, researchers seek to select the model which best explains the data. Model fit is one of two key areas of consideration when selecting the final model; the other is the substantive interpretation and evaluation of the structural relationships between indicators and the latent variable(s) for the groups generated (Masyn, 2013).

Model fit can be described in terms of absolute model fit (the overall fit of a model to the data) and relative fit (a comparison of the fit of two specific models to a given set of data) (Masyn, 2013). Absolute fit is examined using model-based hypothesis tests to compare the observed covariance matrix for all pairs of indicators to that predicted by the estimated parameters (Biemer, 2010). However, the validity of these tests is poor in situations where the sample size is small and/or the number of indicator variables is large (Biemer, 2010).

The following model fit information was used to select the model which best fit the data:

i) **The Loglikelihood G^2 statistic**- the relative fit of two nested models (e.g. an unconstrained and constrained model) for the same data may be compared via the difference in the loglikelihood statistic. A lower loglikelihood statistic indicates that the model fit less well than the comparison (Nylund et al., 2007). The significance of any difference in loglikelihood statistic can be examined for using a chi-squared distribution test, with degrees of freedom equal to the number of parameters that are constrained. However the G^2 statistic should not be used to compare models with different numbers of classes (Nylund et al., 2007).

ii) **Parsimony indices/ information criteria** – Akaike information criterion (AIC) and Bayesian information criterion (BIC) are model indices based on the value of -2 times the loglikelihood of the model with adjustment for the number of parameters in the model. They are usually written in the form (-2logL + kp), where L is the likelihood function, p is the number of parameters in the model, and k is 2 for AIC and log(number of observations) for BIC (Dziak et al., 2012). Due to differences in how they penalise free parameters (2*k in AIC; ln(N)*k in BIC), the AIC may overfit the data, whereas the BIC is more likely to underfit the data (Burnham & Anderson, 2004).The measures are used to compare the fit of models with different numbers of classes or covariates, with the model with the lowest value for the information criteria being selected (Masyn, 2013; Burnham & Anderson, 2004). AIC is better in situations when a false positive is preferable over a false negative, and BIC is better in situations where a false positive is as misleading as, or more misleading than, a false negative (Dziak et al., 2012).

iii) **Entropy** - a summary statistic which indicates how much uncertainty there is in the model's ability to correctly allocate cases to a latent variable group (Masyn, 2013). It is based on the posterior class membership probabilities, which are the probabilities that, given a case's correct group, the model assigns them to it. The values of entropy ranges from 0 to 1, with scores close to 1 indicating better quality of the classification in terms of confidence in correct allocation and clear classifications (Muthén & Muthén, 2015). A cut-off of 0.8 has been suggested for defining 'high entropy' values (Clark & Bengt, 2009).

INTERPRETATION OF LCA RESULTS

The key LCA outputs and how they are interpreted are described below:

Case level:

i) Class membership probabilities - the probability that an individual case belongs in a specified class given their observed indicator responses. A probability is generated, using the measurement model, for each possible class and saved as additional variables.

In any given LCA model each individual has a probability of belonging in each of the possible groups. In a well-fitting LCA model individuals have a high probability of belonging in one of the groups (i.e. probability >0.7), and a low probability of belonging in each of the remaining groups. If an individual's probability for all groups is similar, this suggests a lack of confidence in the model's ability to identify distinctive groups.

Class level:

i) Class frequencies – the number of cases in each class based upon a) most likely class (where each case contributes to a single class) and b) the estimated model using posterior probabilities (weighted frequencies, where each case contributes proportionally to a class according to their probability of membership in that class).

ii) Class average posterior probabilities – the average posterior probability across all cases for membership in a given class. High probability averages corresponding to individuals being allocated to their most likely class, and low probability averages corresponding to allocation into remaining classes, suggests high confidence in correct classification for a model.

iii) Conditional probabilities – given a case's most likely class, the model predicts the probability that the case endorses each possible response for every indicator variable. This information is used to interpret and describe the observed characteristics of each class.

To interpret the model findings and identify the characteristics of each group, one should refer to the posterior probabilities of the indicator variables. Very low or very high (e.g., 30% or lower, and 70% or higher) likelihood of endorsing an indicator response can offer clues as to the defining characteristics of the cases who belong in it (Masyn, 2013). The difference between groups should be meaningfully interpretable in terms of the concept which the latent variable is hypothesised to measure. Attention should also be paid to indicator endorsement patterns which are neither predominantly endorsed nor unendorsed. Such ambiguity may suggest an additional underlying group of cases in the sample not currently represented in the model, and supports consideration of a model with a greater number of classes or enhancing the indicator variable set (Masyn, 2013).

Posterior probabilities and entropy can also be used to examine how effective the model is at categorising cases. By examining what proportion of cases have posterior probabilities over a specific cut-off (e.g. 0.8) for their most likely class, one can explore whether cases have a high probability of being in a single class, or have similar probabilities for multiple classes (Masyn, 2013). A model with a high proportion of cases that have high posterior probabilities for their most likely class is preferable, as this suggests the model is able to make confident predictions based upon observed indicator endorsement.

6.2 METHODS

6.2.1 STUDY DESIGN AND SAMPLING FRAME

Community dwelling older participants were recruited into ELSA using multistage-stratified probability sampling as described in Section 5.2.1. The LCA analysis was performed using cross-sectional data collected from respondents providing complete social participation data at wave 2 of ELSA. Wave 2 was selected as it is the earliest time point at which additional social participation variables first became available for the ELSA cohort (Natcen, 2012). This study did not drive the sample size as this was the concern of those responsible for data collection, who selected participants with the purpose of obtaining an adequate number of men and women in each 5-year age band (Steptoe, et al., 2012). Comparison of socio-demographic characteristics with results from the national census found ELSA respondents to be broadly representative of the English older general population (Steptoe, et al., 2012). Using cross-tabulations, the age and gender characteristics of participants included in the LCA were compared to those of the English general older population obtained from census data.

An additional stage of analysis examined associations of sociodemographic and health factors with the identified social participation groups, using a subsample of respondents who provided complete sociodemographic, psychological, physiological and health data. Ethical consent was obtained for all waves and components of ELSA in writing from respondents and ethical approval was obtained from the London Multi-Centre Research Ethics Committee. Consent included that for secondary analysis of the data by researchers adhering to set terms and conditions relating to data security and appropriate use (Cheshire, et al., 2012).

6.2.2 DATA PROCESSING AND CLEANING

Data was processed and cleaned before being made available for secondary data analysis. Closed questions were used primarily, and each response option had an empirical coding value (Natcen, 2012). However, a small number of questions did not use a coding frame. Responses to these open questions were coded into separate variables after the interview was conducted. Interviewers could use the 'other' category option if the respondent's answer did not fit any of the codes or if they were not confident of coding into the prescribed codes (Natcen, 2012). All variables used in this study were checked (by SB) for unexpected values, none were identified.

6.2.3 SOCIAL PARTICIPATION

To identify distinctive social participation, group items capturing one or more aspect of social participation were identified in the ELSA dataset using a systematic screening process. The Lavasseur model of social participation (Lavasseur et al., 2010) was used to identify the screening criteria which were then systematically applied to all 6618 variables in the ELSA dataset. An item was considered to capture social participation if it either explicitly or implicitly (e.g. captured activities which occur within a societal or community context) referred to social activities which fulfilled one or more of:

- interacting with others (with or without sharing a common activity)
- helping others
- contributing to society

Two researchers (SB and TP) independently screened the ELSA dataset against the above criteria. This approach aimed to minimise bias during item selection and support the reliability and accuracy of conclusions (Mulrow & Cook, 1998). To establish a consistent approach to identifying social participation items, the two researchers familiarised themselves with the Levasseur model of social participation (Levasseur et al., 2010) prior to applying the screening criteria, followed by an in-depth discussion of the concept. Then a preparatory exercise was completed in which both reviewers applied the social participation screening criteria to a list of ten possible social participation activities, some of which were purposely designed to spark debate. Discussion around decisions of which represented social participation, and any differences which arose, were used to promote a consistent application of the screening criteria to the ELSA variables by the two reviewers.

Each reviewer then independently categorised each ELSA variable according to whether or not it fulfilled the above criteria: 'Yes' / 'No' / 'Maybe'. A Kappa coefficient was calculated to assess the reliability of decisions between the two reviewers (Sim & Wright, 2005). The Kappa coefficient of 0.65 demonstrated good initial agreement between reviewers. A consensus meeting was held to discuss any disagreements between the reviewers. Discussion of how the items were interpreted in relation to the screening criteria resulted in consensus on these items being established, and all 6618 ELSA variables were categorised as either fulfilling or not fulfilling the social participation criteria.

Included ELSA variables were then reviewed to remove duplication of information across variables and poor quality items. Poor quality items were those with high levels of missing data (>10% of ELSA respondents) or poor ability to discriminate between individuals due to >95% endorsing one response. If responses were categorical then they were discarded if the cumulative percent of respondents reporting some degree of fulfilment was <5%.

6.2.4 SOCIODEMOGRAPHIC AND HEALTH CHARACTERISTICS

To test whether the social participation groups demonstrated differences in terms of their health and wellbeing, the social participation groups were described according to sociodemographic and health characteristics. These characteristics included age, gender, economic adversity, musculoskeletal pain, physical health, mental health and chronic limiting illness, as described in Chapter Five (Section 5:4). Additionally, physical disability was included as a descriptive outcome in the LCA study. Physical disability is associated with social participation restriction (Wilkie et al., 2007), but conceptually distinctive

(Badley, 2008). Therefore, the association of physical disability with each social participation group was explored to examine to what extent the social participation groups were driven by levels of disability. Physical disability captured activity limitation, as defined in the ICF (WHO, 2001), from self-reported difficulties with ten motor function indicators (walking 100 yards; sitting for two hours; getting up from a chair after sitting for long periods; climbing several flights of stairs without resting; climbing one flight of stairs without resting; stooping, kneeling, or crouching; reaching or extending either arm above shoulder level; pulling or pushing large objects like a living room chair; lifting or carrying weights over 10 pounds; and picking up a 5p coin from a table), six functional Activities of Daily Living (ADLs) (dressing, including putting on shoes and socks; walking across a room; bathing or showering; eating, such as cutting up your food; getting in or out of bed; and using the toilet, including getting up or down) and seven Instrumental Activities of Daily Living (IADLs) (using a map; preparing a hot meal; shopping for groceries; making telephone calls; taking medications; doing work around the house or garden; and managing money). A total score ranging from 0 to 23 was constructed and sub-divided into three categories: no disability (score 0), mild disability (1–6) and severe disability (7–23) (Tabassum et al., 2009).

6.2.5 STATISTICAL ANALYSIS

IDENTIFICATION OF SOCIAL PARTICIPATION GROUPS

As outlined above, LCA creates one categorical variable with a pre-specified number of groups from a number of observed items; with each category including individuals with similar characteristics (Lanza & Rhoades, 2013). The identified items capturing social participation in ELSA (method described in Section 5.3.3) were then applied in the LCA. Starting with a one class model, a series of LCA models was constructed, with the number of social participation groups in the latent variable increasing by one at each step, until the proportion of total respondents within the smallest class dropped below the recommended cut-off of 10% (Jung & Wickrama, 2008). Information about fit (including log likelihood, Akaike Information Criterion (AIC), adjusted Bayesian Information Criterion (BIC) and the entropy) were used to indicate the comparative fit of the LCA models with different numbers of latent classes (Collins & Lanza, 2010). The final model was the one which offered a comparatively better fit to the data (see Section 5.2.6.3). In brief, a smaller AIC/BIC value is preferable, and entropy values tending towards 1 (Collins & Lanza, 2010). The certainty of group allocation was tested by examining the proportion of individuals with a posterior probability ≥0.7 of being assigned to their most likely group. Finally, the interpretability and meaningfulness of the social participation profiles, when applied to an older population, was used to examine the applicability of the best fitting models. In this way both theory and empirical information were used to identify the best model for the data.

DISTRIBUTION OF SOCIODEMOGRAPHIC AND HEALTH FACTORS WITHIN SOCIAL PARTICIPATION GROUPS

The distribution of sociodemographic, health and wellbeing factors were analysed for a subset of participants who provided complete covariate data. Results are presented as counts and proportions as all variables were categorical or binary variables. Differences between groups were tested for using chi-square tests and Bonferroni-adjusted P-values. Multinomial logistic regressions were used to examine associations between social participation groups and sociodemographic and health factors, and then all factors were combined in a multivariable model. Those who engaged in the least social participation activities were the referent group to which other groups were compared. Results are expressed as relative risk ratios (RRR) and bootstrapped 95% confidence intervals were calculated for all coefficient estimates (with 10000 draws), as they allow for asymmetrically distributed parameter estimations to be accommodated for. RRRs are a measure of difference in risk (i.e. likelihood) of an exposure in comparison group compared to that of a given referent group (Szklo & Nieto, 2014). Sensitivity analyses were performed using full information maximum likelihood estimation to account for missing covariate data.

6.3 MISSING DATA

6.3.1 WHAT IS MISSING DATA?

Missing data in cohort studies may either be due to item non-response (where one or more items are unanswered), or case non-response (where a participant fails to return the survey. Missing data is an important consideration in cohort studies; it can reduce the statistical power of a study and can produce biased estimates, leading to invalid conclusions (Karahalios et al., 2012). The decision of how best to deal with missing data is dependent on what data is missing (e.g. independent or dependent variable data), and the underlying mechanism.

Data are said to be 'missing at random' if missingness is unrelated to actual values of observed data in the study (Karahalios et al., 2012). Data are said to be 'missing not at random' if the likelihood of being missing is due to the missing data value even after taking into account all the observed variables (Karahalios et al., 2012). For instance, very ill people may be less likely to return a postal health survey, and so be more likely to have missing outcome data. Such data are 'non-ignorable' as analysis of the available data alone will typically be biased. The best possible method of handling the missing data is to prevent the problem by well-planning the study and collecting the data carefully. However, it is often inevitable that missing data will occur, and when it does there are four principal options for dealing with it; complete case analysis, imputation, likelihood based approaches and weighted analysis (Karahalios et al., 2012).

6.3.2 DEALING WITH MISSING DATA

Transparent reporting of the amount of missing data, the reasons for non-participation and non-response, and the method used to handle missing data in the analyses should be stated when reporting cohort studies (Sterne, et al., 2009;von Elm, et al., 2007). In this study missing data was deemed to be missing not at random, as those with poor health and/or infrequent social participation were most likely to be excluded from the analytical samples due to missing data (differences are reported in Section 8.6). In the quantitative analyses in this thesis, to examine for potential bias due to missing data, sensitivity analyses were performed using full information maximum likelihood estimation to account for missing covariate data. The association estimates were then compared to the complete case analyses.

Likelihood based approaches are suitable for dealing with data missing not at random, and rather than impute the missing data the uncertainty arising from missingness is handled within the analysis model. They are also recommended for use in complex models (Karahalios, et al., 2012). FIML does not replaced or imputed missing values, but the missing data is handled within the analysis model (Muthén & Muthén, 2015). The process works by estimating a likelihood function for each individual based on the variables that are present so that all the available data are used. A disadvantage of maximum likelihood approaches to missing data is that equations need to be specifically worked out for a given distribution and estimation problem, which often requires complex statistical know-how, particularly if confidence intervals for the parameters are desired (Horton & Kleinman, 2007). However statistical packages are increasingly able to handle such complex techniques. Simple counts and descriptive statistics (i.e. between group comparisons of variable responses) were performed using IBM SPSS Statistics 21. All multinomial regression and LCA models were estimated using MPlus version 7.2 (Muthén & Muthén, 2015).

6.4 RESULTS

6.4.1 IDENTIFICATION OF SOCIAL PARTICIPATION ITEMS IN ELSA

Of the 6618 items in the ELSA dataset; 6545 did not measure social participation (and were excluded), 72 did measure social participation (and were retained) and the inclusion of 1 item could not be agreed upon. This remaining item[8] was discussed with the supervisory team, and subsequently excluded. The data of the 72 retained items were reviewed to remove duplication of information and poor quality items. A total of three items had <5%

[8] The item captured whether or not an individual felt they had been adequately appreciated for caring for others. It was decided that, despite being contingent upon fulfilment of a social role, this item captured satisfaction rather than activity performance.

events for the sample so demonstrated poor ability to discriminate between individuals and were discarded. A further two variables were discarded as inspection of the responses found they related to satisfaction rather than performance, and one item lacked the necessary specificity to be certain activities were socially orientated so was discarded.

Of the 66 remaining items, those which were conceptually similar but provided differing information were merged and coded into a hybrid variable. For example, frequency of mild sport, frequency of moderate sport and frequency of vigorous sport were summed to give an overall frequency of sport. Similarly, 4 individual questions asking if the individual lived with a child/grandchild/mother/father were combined to form a variable capturing intergenerational living. Two variables (cohabiting status and intergenerational living), although conceptually different, lacked sufficient distinction and were highly correlated (>0.8) so intergenerational living was discarded. In total, 26 variables were then taken forwards for the LCA. This process is illustrated in Figure 6:1 below.

The final variables captured three dimensions of social participation; interactions with social network members (e.g. contact with friends, family and relatives respectively), recreational activities with others (e.g. going to the theatre/cinema, visiting museums/galleries, eating out and taking a holiday), and contributing to society or helping others (e.g. being a carer, volunteering, and/or being a member of a group, club or organisation). These social participation dimensions corresponded to the dimensions of social activities given in the Levasseur model of social activities (Figure 2:2; Chapter Two). The 26 variables are listed in Table 6:1.

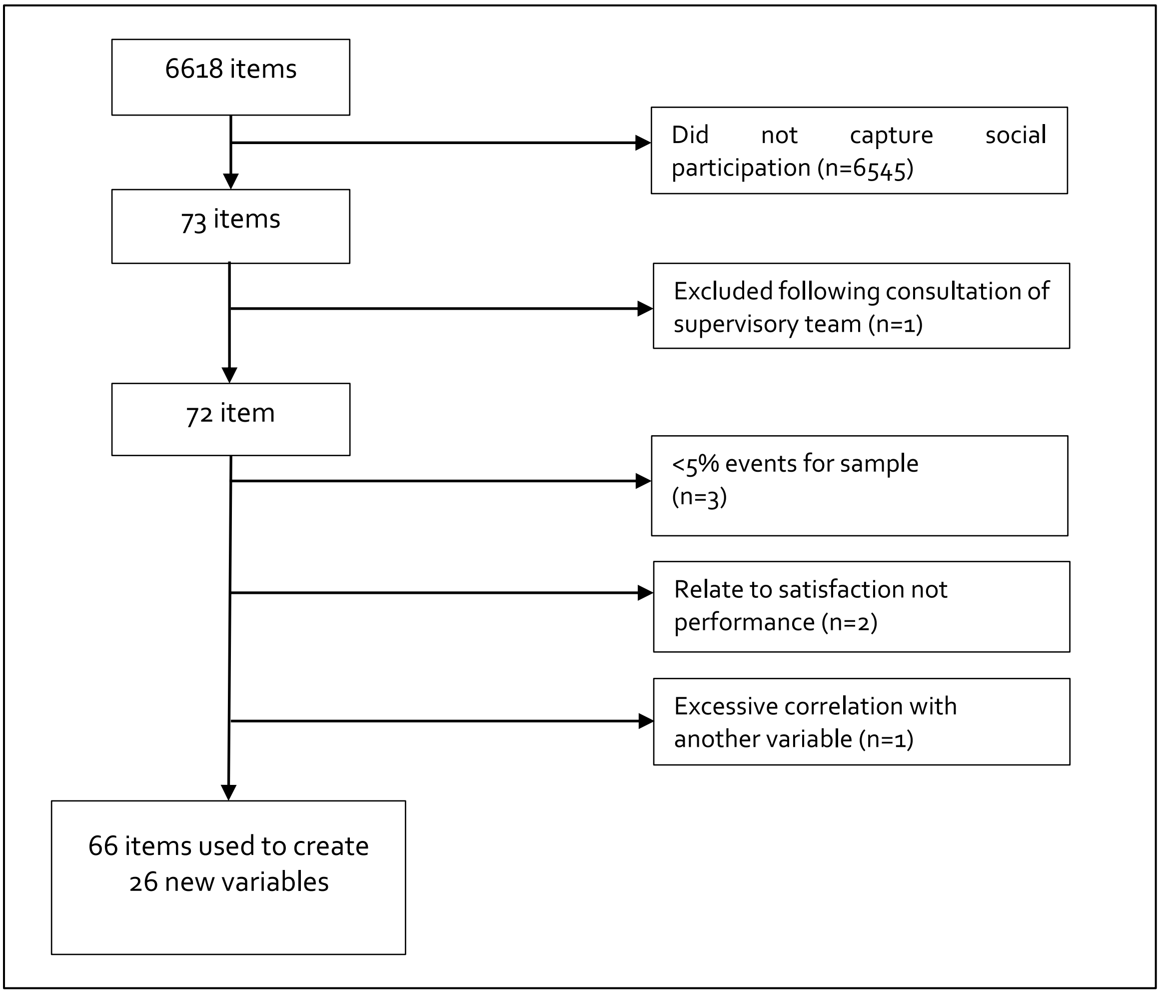


Figure 6:1 The ELSA item sorting process, from identification of items fulfilling aspects of social participation to final variable selection

Table 6:1 Details of the 26 variables extracted from ELSA items for the LCA

Variable	Response options or categories
Lives alone	Yes/No
Lives with partner	Yes/No
Lives with others (but not partner)	Yes/No
Contact with children	(<weekly/has none)/(Once/twice a week)/(3+ a week)
Contact with friends	(<weekly/has none)/(Once/twice a week)/(3+ a week)
Contact with relatives	(<weekly/has none)/(Once/twice a week)/(3+ a week)
Homemaker	Yes/No
Carer	Yes/No
Goes to the cinema	Monthly or more/less than monthly
Visits museums or art galleries	Monthly or more/less than monthly
Goes to the theatre, concert or opera	Monthly or more/less than monthly
Taken a UK holiday in last 12 months	Yes/No
Taken a holiday abroad in last 12 months	Yes/No
Taken 1+ daytrips in last 12 months	Yes/No
Eats out	Monthly or more/less than monthly
Employed	Yes/No
Completing training/ educative activities	Yes/No
Doing voluntary work	Monthly or more/less than monthly
Member of a charity organisation	Yes/No
Member of a neighbourhood group	Yes/No
Member of a political	Yes/No
Member of a church/religious	Yes/No
Member of an educational/arts	Yes/No
Member of a social group	Yes/No
Member of a sport/exercise group/organisation	Yes/No

6.4.2 STUDY PARTICIPANTS

Of the 9432 respondents [consisting of 8781 (82%) of original baseline respondents plus the addition of new or younger partners (n=652)] to ELSA in this wave, 261 of these respondents were less than 50 years old, and were excluded. The age and gender distributions of the 9171 respondents were comparable to population estimates for England (ONS, 2014) and are provided in Table 6:2.

Table 6:2 The age and gender distribution of the English population and ELSA respondents

	English Population[9]		ELSA respondents	
	Male	Female	Male	Female
50-59	17.6%	17.9%	15.1%	18.7%
60-69	15.1%	15.8%	15.7%	17.3%
70-79	9.5%	10.8%	10.2%	11.8%
80+	5.1%	8.3%	4.6%	6.6%
Total	47.2%	52.8%	45.6%	54.4%

Of the 9171 respondents, 1905 (21%) had incomplete social participation data, leaving a total study sample of 7266 (77% of the all respondents) for LCA. Compared to those with complete social participation data, the group providing incomplete data had proportionally fewer men (40.6% cf 45.6%; $p<.001$) and youngest old [age 50-54 years (37.8% cf 51.0%; $p<.001$)]. Those with incomplete social participation data were on average

[9] ONS Population estimates tool (2013 estimate) http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/2013/index.html

less wealthy (mean [standard deviation]) non pension wealth £213,642 [262,345] cf £278,856 [419,818]; $p<.001$) than those who provided complete social participation data. Overall only 2.4% of respondents identified as being of non-white ethnicity, and there was no significant difference between those providing complete and incomplete social participation data ($p=.394$).

A summary of the social participation profile for those with complete social participation data is provided in Table 6:3. Contact with others was fairly common for the overall sample. Over half of the participants lived with a partner or spouse (n=4517; 62.2%), and a further 875 (12.0%) lived with people other than a partner or spouse. Two-thirds of participants (n=4794; 66.0%) had children and spoke to them at least weekly, while friends and relatives were less likely to be seen weekly (n=4127; 56.8%, and n=3207; 44.1% respectively). Many of the older people pursued social activities away from their home. Half of the participants reported visiting the cinema, museums and galleries and/or theatres or shows in the last year, while the remaining 3414 (50.0%) visited none of these. Holidays and/or daytrips had been taken by three quarters of respondents within the preceding year (n=5416; 74.5%). Just over half of participants (n= 4265; 58.7%) were members of one or more types of organisation or groups (charitable organisations, neighbourhood groups, political organisations, religious groups, educational or arts groups or evening classes, social groups, and sports or exercise groups). Two in every five older people was a member of one or more groups or organisations, suggesting that many older people pursue a variety of different social activities.

Table 6:3 The distribution of social participation characteristics in those included in the LCA (N=7266)

Social participation indicator variables	Category	n	% of total sample
Social role: living companion	*Live with spouse/partner*	*4517*	*(62.2%)*
	Live with others	*875*	*(12.0%)*
	Live alone	*1874*	*(25.8%)*
Contact with children	*3+ times a week*	*2522*	*(34.7%)*
	once/ twice a week	*2272*	*(31.3%)*
	< weekly/has none	*2472*	*(34.0%)*
Contact with relatives	*3+ times a week*	*1165*	*(16.0%)*
	once/ twice a week	*2042*	*(28.1%)*
	< weekly/has none	*4059*	*(55.9%)*
Contact with friends	*3+ times a week*	*1340*	*(18.4%)*
	once/ twice a week	*2787*	*(38.4%)*
	< weekly/has none	*3139*	*(43.2%)*
Social role: homemaker	*yes*	*3566*	*(49.1%)*
Social role: carer	*yes*	*1060*	*(14.6%)*
Social role: volunteer and/or employed	*yes*	*3003*	*(41.3%)*
Educational activities	*yes*	*515*	*(7.1%)*
Recreational outings in the last year	*Cinema*	*2326*	*(32.0%)*
	Museums/galleries	*2248*	*(30.9%)*
	Theatre/shows	*2848*	*(39.2%)*
	None of these	*3414*	*(50.0%)*
Eating out	*Once a month or more*	*3335*	*(45.9%)*
Excursions	*Holidays in UK/Abroad*	*4800*	*(66.1%)*
	Daytrips	*4194*	*(57.7%)*
	None of these	*1850*	*(25.5%)*
Organisation membership(s)	*Two or more*	*2299*	*(41.3%)*
	One	*1966*	*(27.1%)*
	None	*3001*	*(31.6%)*

6.4.3 IDENTIFICATION OF SOCIAL PARTICIPATION GROUPS

MODEL SELECTION

Starting with a model with only one class, and increasing the number of classes by one each time, a total of six latent class models were investigated. At the 6 class model the proportion of participants within the smallest class dropped below the pre-specified cut-off of 10%, consequently no further models were investigated. The best loglikelihood was replicated in all models, indicating replicable, and therefore trustworthy, solutions. MPlus provided a warning for all models tested that all variables were uncorrelated within a group, indicating the assumption of conditional independence was met (Muthén & Muthén, 2015). The class proportions and fit indices are provided in Table 6:4. The four class model provided the optimal categorisation of the study sample when both the model fit indices and the social participation characteristics of individual groups were interpreted.

First the fit indices were used to narrow the choice of optimal models down. Across the six models the AIC and adjusted BIC continued to decrease, although the magnitude of reduction was <1% between the models with 4 and 5 classes suggesting negligible improvement. The entropy values for the models remained ≥0.8 for all models examined. The proportion of individuals with a posterior probability of ≥0.7 for being assigned to their most likely group was 92.5% for the three-class model, 84.2% for the four-class model, and 77.8% for the five-class model respectively. As there was minimal improvement in fit indices following the four class model, the three and four class models were selected for further evaluation by interpretation of the social participation characteristics of the component groups.

Table 6:4 Model fit indices and sample proportions in each class for LCA models with 1 to 6 classes (N=7266)

LCA model:		1 class	2 class	3 class	4 class	5 class	6 class
Information fit indices*:	AIC:	206791	188993	182874	181614	180836	180263
	AIC diff:	n/a	-8.60%	-3.20%	-0.70%	-0.40%	-0.30%
	Adj BIC:	206977	189197	183182	182027	181352	180883
	BIC diff:	n/a	-8.60%	-3.20%	-0.60%	-0.40%	-0.30%
Entropy #:		n/a	0.88	0.86	0.79	0.76	0.78
Entropy change:		n/a	n/a	-2.30%	-8.20%	-4.50%	3.30%
n (%) Class 1		7266 (100%)	5075 (69.4%)	3186 (43.8%)	2009 (27.6%)	1107 (15.2%)	1335 (18.4%)
Class 2			2191 (30.6%)	1110 (15.3%)	1091 (15.0%)	1266 (17.4%)	1064 (14.6%)
Class 3				2970 (40.9%)	2762 (38.0%)	2468 (34.0%)	2495 (34.3%)
Class 4					1404 (19.3%)	1361 (18.7%)	1060 (14.6%)
Class 5						1064 (14.6%)	1250 (17.2%)
Class 6							62 (0.85%)

** For AIC and adjusted BIC a decrease indicates an improvement in model fit to the data*
 # an Entropy value closer to 1 indicates greater confidence in cases most likely class being their true class

When the social participation characteristics which defined the profiles of each group were compared for the three class and four class models, the four class model further distinguished between high and low levels of formal community engagement (i.e. membership in organisations and formal groups) within frequent socialisers, whilst in the three class model individuals with both high and low levels of formal community engagement were allocated to a single, common group. When compared to the four-class model, the social participation profiles of the five-class model were less readily interpretable than those of the four class model, and group allocation was less certain (77.8% of posterior probabilities ≥0.7, compared to 84.2% in the four class model). The group which consisted of those participants who did very little social participation was consistent and stable, with less than <1% of the total sample moving to alternate groups between models 2 to 5.

THE FOUR-CLASS LCA MODEL

The social participation characteristics of the four groups derived by the four-class model are summarised in Table 6:5. The groups were named according to their overall social participation patterns as; "*frequent high community engagement*" (n=1404; 19.3%), "*frequent low community engagement*" (n=2009; 27.6%), "*moderate*" (n=2762; 8.0%), and "*infrequent*" (n=1091; 15.0%) socialisers.

Table 6:5 The social participation characteristics of each of the four class model groups

Group	Size of group (n[#])	Description
Frequent socialisers, high community engagement	19.3% (n=1404)	Live with their spouse/ partner or alone See children and friends weekly or more Unlikely to be employed Visits museums and galleries Attends theatre shows and the cinema Eat out often Take holidays/ daytrips Likely to be a member of charity, religious, educational, sporting c neighbourhood groups
Frequent socialisers, low community engagement	27.6% (n=2009)	Live with their spouse/ partner See children and friends weekly or more Likely to be in employment Visits museums and galleries Attends theatre shows and the cinema Eat out often Take holidays/ daytrips May be a member of a social, sport or exercise related group
Moderate socialisers	38.0% (n=2762)	Live with a spouse/ partner or alone See children and friends weekly or more Unlikely to be employed Do not go on recreational outings (e.g. theatre, museums) May take holidays/ daytrips Unlikely to be a member of a social organisation or club
Infrequent socialisers	15.0% (n=1091)	Live alone or with those other than partner/spouse Do not have, or do not regularly see, children and friends Unlikely to be employed Do not go on recreational outings (e.g. theatre, museums) Do not take holidays/ daytrips Are not members of any groups or organisations

[#] Participants assigned to their most likely group membership

The two frequent socialiser groups were similar, sharing many of the same social activities and seeing friends and family often. However, an important difference was found in terms of their social engagement activities. The frequent high community engagement (FreqHigh) group were more likely to be members of one or more formal group or organisation than the frequent low community engagement (FreqLow) group. Furthermore, the FreqHigh group were not as likely to live with others, or to be employed as the FreqLow group were.

The moderate socialiser group had frequent social interaction, but this was less contingent on visiting other places, for example few visited the theatre or museums and levels of engagement in organisations and groups was minimal. Informal social activities which are often linked to spending time with family and friends, such as going on holidays and eating out, were reported by many moderate socialisers.

Infrequent socialisers were the group least likely to engage in leisure-related social activities outside of their home or be a member of a group or organisation. Those who did have family and friends reported seeing them less than weekly. However, one in four infrequent socialisers reported being employed. Expected and observed probabilities for each social participation indicator used in the LCA are provided in full in Table 6:6.

Table 6:6 Conditional probabilities of endorsing each social participation indicator and the observed proportions of cases who did so in each of the groups in the four class model (N=7266). (Part 1)

	Frequent socialisers, high community engagement		**Frequent socialisers, low community engagement**		**Moderate socialisers**		**Infrequent socialisers**	
	Conditional probability	*Observed proportion (%)*	*Conditional probability*	*Observed proportion (%)*	*Conditional probability*	*Observed proportion (%)*	*Conditional probability*	*Observed proportion (%)*
Lives alone	0.236	23.7	0.127	11.7	0.304	30.9	0.415	41.4
Lives with partner	0.732	73.1	0.850	86.0	0.641	63.5	0.006	00.8
Lives with others (but not partner)	0.032	3.2	0.023	2.3	0.056	05.6	0.579	57.7
Children:								
<weekly/has none	0.213	20.9	0.205	20.2	0.250	25.3	0.986	98.4
Once/twice a week	0.419	42.5	0.403	40.3	0.312	31.1	0.005	0.5
3+ a week	0.368	36.6	0.393	39.5	0.438	43.6	0.009	1.0
Friends:								
<weekly/has none	0.233	22.5	0.367	36.8	0.364	36.3	0.991	99.2
Once/twice a week	0.503	50.7	0.474	47.6	0.405	40.5	0.003	0.1
3+ a week	0.264	26.8	0.159	15.6	0.231	23.2	0.006	0.7
Relatives:								
<weekly/has none	0.472	47.4	0.491	48.8	0.479	47.9	0.998	1.00
Once/twice a week	0.350	34.5	0.357	36.1	0.300	30.2	0.001	0.0
3+ a week	0.178	18.1	0.152	15.1	0.221	22.0	0.001	0.0
Homemaker	0.649	66.2	0.474	47.5	0.470	46.8	0.360	35.7
Carer	0.237	24.3	0.141	14.3	0.128	12.6	0.077	7.6
Goes to the cinema	0.600	59.8	0.602	62.9	0.091	08.1	0.000	0.0
Visits museums or art galleries	0.689	70.4	0.505	52.3	0.085	07.6	0.000	0.0
Theatre, concert or opera	0.798	80.8	0.678	70.3	0.119	10.9	0.000	0.0

Table 6:6: Conditional probabilities of endorsing each social participation indicator and the observed proportions of cases who did so in each of the groups in the four class model (N=7266). (Part 2)

	Frequent socialisers, high community engagement		**Frequent socialisers, low community engagement**		**Moderate socialisers**		**Infrequent socialisers**	
	Conditional probability	*Observed proportion (%)*	*Conditional probability*	*Observed proportion (%)*	*Conditional probability*	*Observed proportion (%)*	*Conditional probability*	*Observed proportion (%)*
UK holiday	0.795	79.5	0.740	75.0	0.400	40.0	0.000	0.0
Holiday abroad	0.714	71.9	0.714	72.9	0.299	29.4	0.000	0.0
Daytrips	0.922	93.4	0.823	82.8	0.440	44.1	0.003	0.2
Eats out	0.719	72.2	0.723	73.8	0.308	30.3	0.000	0.0
Employed	0.320	30.3	0.601	61.8	0.234	23.1	0.268	26.8
Training/ education	0.170	17.5	0.082	08.3	0.025	2.5	0.031	3.1
Voluntary	0.501	54.5	0.036	02.0	0.066	6.5	0.064	6.4
Organisation memberships:								
Charity	0.545	58.5	0.081	6.6	0.083	8.4	0.001	0.1
Neighbourhood group	0.415	43.0	0.166	16.7	0.133	13.1	0.000	0.0
Political	0.292	30.3	0.169	16.9	0.077	7.6	0.000	0.0
Church/ religious	0.526	56.6	0.099	8.4	0.159	15.8	0.004	0.4
Educational/arts	0.394	41.4	0.117	11.4	0.033	3.2	0.000	0.0
Social group	0.256	26.3	0.188	18.1	0.196	19.8	0.003	0.3
Sports/ exercise	0.377	38.2	0.289	29.7	0.068	6.4	0.000	0.0

6.4.4 HEALTH AND SOCIODEMOGRAPHIC CHARACTERISTICS OF THE SOCIAL PARTICIPATION GROUPS

CHARACTERISTICS OF SUBSAMPLE PROVIDING COMPLETE COVARIATE DATA

Of the 7266 respondents used in the LCA, a total of 590 (8.1%) provided incomplete data on one or more of; mental health (n=236), self-rated health (n=128), limiting illness (n=3), disability (n=2), and wealth (n=356), resulting in a total of 2187 participants subsequently being dropped from the dataset, leaving a total of 6676 (91.9%) participants providing data for examining associations of health and sociodemographic factors with each social participation group. Of these 6676, almost all were white (97.6%), and 3759 (54.4%) of respondents were female. Approximately half of those providing complete covariate data were aged 50-64 years (n=3379; 50.6%), 2572 (38.5%) were aged 65-79 years and the remaining 725 (10.9%) were aged 80 years or more.

Differences between those who responded with complete covariate data and those with social participation data but incomplete covariate data are provided in Table 6:7. Those with incomplete data were more likely to be male, report musculoskeletal pain and to be allocated to the *infrequent* socialiser group (43.7% cf. 12.5%; $p<.001$). Those of the excluded participants who provided wealth data were twice as likely to experience economic adversity. Participants excluded due to missing data were also less likely to have good self-rated health, had higher chance of reporting chronic limiting illness and were twice as likely (34.9% cf. 14.1%) to report moderate/severe disability.

Table 6:7 Participant characteristics for those excluded due to missing covariate data and those with complete covariate data

Variable with missing data	Excluded due to incomplete covariate data (n=590) %	Complete data (n=6676) %	*p*-value
Social participation group			
Infrequent	258 (43.7%)	833 (12.5%)	p<.001
Moderate	214 (36.3%)	2548 (38.2%)	
FreqLow	72 (12.2%)	1937 (29.0%)	
FreqHigh	46 (7.8%)	1358 (20.3%)	
Age (grouped)			
50-64 years	324 (54.9%)	3379 (50.6%)	p<.001
65-79 years	179 (30.3%)	2572 (38.5%)	
80 years or more	87 (14.7%)	725 (10.9%)	
Gender			
Female	305 (51.7%)	3651 (54.7%)	p<.001
		-	
Economic adversity			
Highest 80%	161 (68.8%)	5566 (83.4%)	p<.001
Lowest 20%	73 (31.2%)	1110 (16.6%)	
*Missing data**	*356*	-	
Musculoskeletal pain	244 (41.4%)	2399 (35.9%)	p=.009
Depressive symptoms			
≥4 symptoms)	154 (43.5%)	1967 (29.5%)	p<.001
*Missing data**	*236*	-	
Self-rated health			
Good/Very good/Excellent	244 (52.8%)	4993 (74.8%)	p<.001
*Missing data**	*128*	-	
Physical Disability			
Mild	223 (37.9%)	2964 (44.4%)	p<.001
Moderate/Severe	205 (34.9%)	943 (14.1%)	
*Missing data**	*2*	-	
Limiting chronic illness			
Yes	331 (56.4%)	2218 (33.2%)	p<.001
*Missing data**	*3*	-	

SOCIAL PARTICIPATION GROUP HEALTH AND SOCIODEMOGRAPHIC PROFILES

The prevalence of health and sociodemographic characteristics across the four social participation groups are provided in Table 6:8, and differences in the strength of association of these characteristics between each of the most socially active groups and the infrequent group given as relative risk ratios (RRRs) in Table 6:9. Compared to the other age groups, the oldest old (≥80 years) were more likely to be infrequent socialisers, while the youngest group (50-64 years) were more likely to be in the FreqLow group. The FreqHigh group were more likely to be women; two thirds (63.1%) of the group were women, while in the other groups the proportion of women was similar to that of the overall sample (54.7%). The infrequent and moderate socialiser groups were more likely to report economic adversity than the FreqLow and FreqHigh groups (36.0% and 24.8%, compared to 4.9% and 6.3%).

There were similar levels of mild disability across all social participation groups (ranging between 41.8%-46.6%), however moderate/severe disability was much higher in infrequent socialisers (27.6%) and moderate socialisers (21.0%) compared to FreqLow (4.2%) and FreqHigh (7.1%). Infrequent and moderate socialisers were less likely to report good self-rated health than either frequent socialiser groups (55.6% and 64.6% respectively, compared to 87.8% and 87.2%). Limiting chronic illness was reported by 47.2% of infrequent socialisers, 42.4% of moderate socialisers, but only 18.8% of FreqLow socialisers and 28.0% of FreqHigh socialisers. Multinomial regression analysis showed that, even when differences in health and sociodemographic factors (i.e. the covariates) were accounted for, infrequent socialisers remained significantly more likely to report economic adversity than any of the three remaining groups.

When the associations between each covariate (adjusted for age and gender) were examined, with infrequent socialisers as the referent group, FreqHigh and FreqLow socialiser groups were less likely to report economic adversity, were approximately half as likely to report musculoskeletal pain, and had fewer depressive symptoms (RRR's with 95%CIs reported in Table 6.9). Good self-rated health was over five times as likely to be reported by the FreqHigh and FreqLow groups compared to infrequent socialisers (RRR:5.07 [95%CI:4.30,6.22] and 5.12 [95%CI:4.49,6.19] respectively), and moderate/severe disability and limiting illnesses were less commonly reported. The lower levels of association with musculoskeletal pain found in FreqLow and FreqHigh socialisers were attenuated to insignificance when other health factors were added in the fully adjusted multinomial regression model, while moderate socialisers became significantly more likely to report musculoskeletal pain (RRR:1.38 [95%CI:1.10,1.66]) than infrequent socialisers.

The multinomial regression model showed that the FreqHigh and FreqLow groups were more likely to have lower levels of physical disability, better self-rated health and fewer depressive symptoms than infrequent socialisers even when differences in sociodemographic and other health factors across the groups were accounted for. In many respects the two frequent social participation groups were similar; both being more than twice as likely to report good health than infrequent socialisers, and more than half as likely to report ≥4 depressive symptoms. Differences in levels of association with limiting chronic illness across the social participation groups attenuated once other health and sociodemographic factors were accounted for in the multivariable model, with only FreqLow socialisers significantly differing from infrequent socialisers, being less likely to report chronic limiting illness (RRR:0.73 [95%CI:0.49,0.90]).

Table 6:8 Participant characteristics by allocated social participation group, with significance of chi-square test for between group differences in distribution, and overall prevalence for those with complete covariate data (n=6676)

	Social participation groups					Overall
	Infrequent socialisers (n=833)	Moderate socialisers (n=2548)	Frequent socialisers, low community engagement (n=1937)	Frequent socialisers, high community engagement (n=1358)	*p*-value	n
Number lost due to missing covariate data[1]	258 (23.6%)	214 (7.7%)	72 (3.6%)	46 (3.3%)	p<.001	590 (8.1%)
Age (grouped)						
50-64 years	312 (37.5%)	1020 (40.0%)	1399 (72.2%)	648 (47.7%)		3379 (50.6%)
65-79 years	311 (37.3%)	1151 (45.2%	484 (25.0%)	626 (46.1%)		2572 (38.5%)
80 years or more	210 (25.2%)	377 (14.8%)	54 (2.8%)	84 (6.2%)	p<.001	725 (10.9%)
Gender						
Female	461 (55.3%)	1343 (52.7%)	990 (51.1%)	857 (63.1%)	p<.001	3651 (54.7%)
Economic adversity						
Lowest 20%	300 (36.0%)	631 (24.8%)	94 (4.9%)	85 (6.3%)	p<.001	1110 (16.6%)
Musculoskeletal pain	346 (41.5%)	1106 (43.4%)	533 (27.5%)	414 (30.5%)	p<.001	2399 (35.9%)
Depressive symptoms						
≥4 symptoms)	402 (48.3%)	936 (36.7%)	368 (19.0%)	261 (19.2%)	p<.001	1967 (29.5%)
Self-rated health						
Good/Very good/Excellent	463 (55.6%)	1645 (64.6%)	1701 (87.8%)	1184 (87.2%)	p<.001	4993 (74.8%)
Physical Disability						
Mild	348 (41.8%)	1179 (46.3%)	804 (41.5%)	633 (46.6%)		2964 (44.4%)
Moderate/Severe	230 (27.6%)	536 (21.0%)	81 (4.2%)	96 (7.1%)	p<.001	943 (14.1%)
Limiting chronic illness	393 (47.2%)	1080 (42.4%)	365 (18.8%)	380 (28.0%)	p<.001	2218 (33.2%)

All values are count (proportions). Bonferroni-adjusted p values were used to test pair-wise comparisons between groups for each categorical covariate.

[1] Proportion uses number in that group as identified in the LCA as denominator (i.e. proportion with missing data overall = n/7266)

Table 6:9 Multinomial logistic regression models showing relative risk ratios (RRR) and 95% confidence intervals for age and gender adjusted analyses and then multivariable analyses with infrequent socialisers as referent group

	Age and gender adjusted associations[a]			Multivariable associations[b]		
	Moderate socialisers (n=2548)	Frequent socialisers, low community engagement (n=1937)	Frequent socialisers, high community engagement (n=1358)	Moderate socialisers (n=2548)	Frequent socialisers, low community engagement (n=1937)	Frequent socialisers, high community engagement (n=1358)
Age						
50-64 years (ref)	--	--	--	--	--	--
65-79 years	1.13 (0.99,1.37)	0.35 (0.28,0.40)	0.98 (0.78,1.22)	1.16 (1.00,1.43)	0.41 (0.32,0.48)	1.13 (0.87,1.39)
80 years or more	0.55 (0.40,0.65)	0.06 (0.04,0.08)	0.19 (0.14,0.25)	0.61 (0.48,0.73)	0.10 (0.08,0.13)	0.30 (0.21,0.38)
Gender						
Female	0.93 (0.72,1.04)	0.87 (0.72,1.02)	1.45 (1.22,1.66)	0.96 (0.76,1.07)	1.04 (0.85,1.18)	1.73 (1.43,2.00)
Economic adversity						
Lowest 20%	0.62 (0.48,0.71)	0.11 (0.09,0.15)	0.13 (0.10,0.17)	0.66 (0.52,0.74)	0.15 (0.12,0.20)	0.17 (0.13,0.23)
Musculoskeletal pain	1.11 (0.87,1.26)	0.57 (0.44,0.68)	0.62 (0.53,0.73)	1.38 (1.10,1.66)	1.31 (0.90,1.61)	1.27 (0.95,1.59)
Depressive symptoms						
≥4 symptoms)	0.65 (0.56,0.79)	0.29 (0.24,0.37)	0.26 (0.21,0.31)	0.68 (0.58,0.80)	0.46 (0.38,0.60)	0.39 (0.32,0.48)
Self-rated health						
Good/Very good/Excellent	1.42 (1.21,1.65)	5.07 (4.30,6.22)	5.12 (4.49,6.19)	1.37 (1.08,1.59)	2.64 (1.86,3.28)	3.36 (2.76,4.25)
Physical Disability						
Mild	1.23 (1.00,1.47)	1.19 (0.99,1.38)	1.25 (1.03,1.46)	1.22 (1.03,1.48)	1.13 (0.91,1.35)	1.10 (0.91,1.41)
Moderate/Severe	0.78 (0.59,0.91)	0.16 (0.11,0.20)	0.23 (0.19,0.29)	1.08 (0.82,1.52)	0.53 (0.39,0.78)	0.61 (0.44,0.92)
Limiting chronic illness	0.88 (0.73,1.02)	0.32 (0.25,0.37)	0.48 (0.41,0.55)	1.01 (0.78,1.23)	0.73 (0.49,0.90)	1.20 (0.93,1.52)

Values in grey text are not statistically significant at p=.05 level.

[a] Each variable adjusted for age and gender (age and gender variables were adjusted for the other respectively), [b] All variables included in the model

SENSITIVITY ANALYSIS

When the multivariable model was rerun using FIML to account for missing covariate data (results shown in Table 6:10), the conclusions were similar, with only two key differences identified. Firstly, the association of musculoskeletal pain, rather than being insignificantly different to that of infrequent socialisers, was significantly higher for FreqLow and FreqHigh socialisers, despite all 7266 participants having complete musculoskeletal pain data. The size of these associations was notable and greater than estimates from the complete case analysis, with RRRs of 1.73 (95%CI:1.71,2.04) and 1.69 (95%CI:1.62,2.29) respectively. Both confidence intervals demonstrated a strong positive skew. Secondly, both mild and moderate/severe physical disability were significantly less likely in moderate socialisers compared to the referent infrequent group, whilst mild disability was found to be more likely, and moderate/severe similar, in the complete case analysis.

Table 6:10 Multinomial logistic regression models showing results of the multivariable[b] analysis for complete cases only and then including missing cases. Infrequent socialisers as referent group and results reported as relative risk ratios (RRR) and 95% confidence

	Complete case multivariable associations[b]			**Missing cases included multivariable associations[b]**		
	Moderate socialisers (n=2548)	Frequent socialisers, low community engagement (n=1937)	Frequent socialisers, high community engagement (n=1358)	Moderate socialisers (n=2762)	Frequent socialisers, low community engagement (n=2009)	Frequent socialisers, high community engagement (n=1404)
Age						
50-64 years (ref)	--	--	--	--	--	--
65-79 years	1.16 (1.00,1.43)	0.41 (0.32,0.48)	1.13 (0.87,1.39)	1.17 (0.98,1.36)	0.43 (0.36,0.48)	1.20 (1.04,1.26)
80 years or more	0.61 (0.48,0.73)	0.10 (0.08,0.13)	0.30 (0.21,0.38)	0.60 (0.51,0.69)	0.11 (0.08,0.13)	0.33 (0.29,0.39)
Gender						
Female	0.96 (0.76,1.07)	1.04 (0.85,1.18)	1.73 (1.43,2.00)	1.02 (0.98,1.09)	1.11 (1.00,1.28)	1.83 (1.62,1.92)
Economic adversity						
Lowest 20%	0.66 (0.52,0.74)	0.15 (0.12,0.20)	0.17 (0.13,0.23)	0.68 (0.60,0.80)	0.16 (0.13,0.20)	0.18 (0.15,0.22)
Musculoskeletal pain	1.38 (1.10,1.66)	1.31 (0.90,1.61)	1.27 (0.95,1.59)	1.90 (1.72,2.19)	1.73 (1.71,2.04)	1.69 (1.62,2.29)
Depressive symptoms						
≥4 symptoms)	0.68 (0.58,0.80)	0.46 (0.38,0.60)	0.39 (0.32,0.48)	0.66 (0.54,0.74)	0.44 (0.34,0.53)	0.38 (0.29,0.49)
Self-rated health						
Good/Very good/Excellent	1.37 (1.08,1.59)	2.64 (1.86,3.28)	3.36 (2.76,4.25)	1.32 (1.10, 1.42)	2.44 (2.02,2.94)	3.15 (2.48,3.70)
Physical Disability						
Mild	1.22 (1.03,1.48)	1.13 (0.91,1.35)	1.10 (0.91,1.41)	0.88 (0.74,0.97)	0.94 (0.82,1.05)	0.94 (0.81,1.03)
Moderate/Severe	1.08 (0.82,1.52)	0.53 (0.39,0.78)	0.61 (0.44,0.92)	0.74 (0.66,0.80)	0.39 (0.35,0.50)	0.43 (0.32,0.52)
Limiting chronic illness	1.01 (0.78,1.23)	0.73 (0.49,0.90)	1.20 (0.93,1.52)	0.95 (0.77,1.01)	0.66 (0.51,0.74)	1.08 (0.89,1.19)

6.5 DISCUSSION

6.5.1 SUMMARY OF FINDINGS

This study used information relating to individuals' social participation activities to categorise them into distinctive groups. These groups, in addition to differences in terms of their social participation profiles, also have different health and socio-demographic profiles, with more frequent social participation associated with better health and lower levels of disability compared to infrequent social participation. Frequent social participation, with or without community engagement, was associated with better mental and physical health and lower levels of disability than infrequent social participation. These findings support previous studies which suggest social participation may be associated with unique health benefits in older people (e.g. Parmelee et al., 2007; Glass et al., 2006). While the proportion of older people in the FreqHigh and FreqLow socialiser groups without musculoskeletal pain were higher, the multivariable analysis suggested membership in these groups was associated with greater likelihood of reporting musculoskeletal pain than the infrequent socialiser group, after adjustment for other sociodemographic and health factors. This may be explained by different individuals demonstrating differing levels of fortification or resistance to the impact of musculoskeletal pain upon their daily activities (Hildon et al., 2008). For example, previous studies suggest some individuals report persisting with social participation activities despite increased musculoskeletal pain (Hermsen et al., 2014; Grime et al., 2010), and multiple chronic diseases (Hermsen et al., 2014), yet others do not.

The higher RRR for musculoskeletal pain in frequent socialiser groups was unexpected, as usually musculoskeletal pain is associated with reduced social participation levels in older people (Wilkie et al., 2016; Wilkie et al., 2013). This association was strongest, and significant in the analyses including those with missing covariate data. However, it is possible that the significant, positive RRR found in FreqHigh and FreqLow groups became stronger once missing data were accounted due to over-adjustment bias. Infrequent socialisers were most likely to report poor mental and physical health and disability as well as musculoskeletal pain, and were also the most likely to be excluded due to missing data. Pain is a complex phenomenon and it is possible that the musculoskeletal pain associated with infrequent social participation differs from that which is associated with maintaining mental and physical health (Jordan et al., 2012), and so was more likely to correlate with factors capturing poor mental and physical health. Furthermore, all measures were binary (with disability modelled as two dummy variables), and so adjustment for limiting chronic illness, self-rated health and depressive symptoms may explain the troublesome pain associated with infrequent social participation, but not pain which does not interfere with daily life and health. This would result in a stronger association with musculoskeletal pain in these participants than those with interfering musculoskeletal pain (which is likely to include infrequent socialisers).

6.5.2 COMPARISON WITH PREVIOUS LITERATURE

Unlike traditional clustering methods, LCA categorises individuals based upon probabilistic modelling using finite mixture distributions, which has been proven to have lower misclassification rates than traditional clustering approaches (e.g. cluster analysis) (Magidson & Vermunt, 2002). The indicator profiles of the four-class model most closely mapped back to the model of social participation used to extract social participation items from the ELSA dataset (Levasseur et al., 2010). The social participation groups identified in this analysis are similar to those of previous studies by Croezen and colleagues (2009) and Hong and colleagues (2009). The Croezen study found a cluster of less socially active older people to be older, living alone, of lower socioeconomic status and in poorer mental and physical health. The Croezen study also found social engagement to be a defining feature between groups, although they reported five distinctive groups rather than four; less socially engaged elderly, less socially engaged caregivers, socially engaged caregivers, leisure engaged elderly and productive engaged elderly. However, the proportion of participants in each group was highly variable, with 50% of participants being in the less socially engaged group, and two groups constituting less than 7% of participants (less socially engaged caregivers and socially engaged caregivers). Clustering solutions with low proportions in one or more groups can be unstable (Field, 2000), however extensive steps were taken to replicate the model in sub-samples and in the entire sample, sorted in a different random order.

In the Hong study, Class 1 was characterized by consistently lower levels of participation across all activities with many activities not performed, and contained 6.5% of older adults. Class 2, contained 46.4% of the sample, who reported moderate levels of eating out (58%), attending religious services (43%), exercising regularly (32%), and attending movies and sports events (9%). Class 3 contained the remaining 47.1%, who reported frequent social participation, especially leisure activities (getting together, talking on the phone with others, going to sports or movies, and eating out). Across all the three groups leisure activities were more frequently performed than productive activities (e.g. working, volunteering, attending religious services, and exercising). Similar patterns in terms of leisure versus productive activities were seen in this study. However, the participants in the Hong study appear to be generally more socially active than the sample used in this study. For example, 69.4% reported eating out (although no information on how variables were dichotomised into yes/no is reported), and 91.6% reported meeting up with others. Furthermore, only a small proportion of participants were allocated to the infrequent class (Class 1). Higher levels of social activity in the sample overall may explain why the Hong study identified 3 classes, rather than the 4 identified in this study.

Social participation restriction was not the focus of this thesis, however it is possible that infrequent social participation was determined primarily by restrictions arising from physical disability and ill health, as found in studies which have described the characteristics of those with social participation restriction (Thomas, 2011; Wilkie et al., 2007). It is also possible that the availability of resources, such as wealth, accounted for some of the variation in social participation activities observed in the sample. Economic adversity was less than a fifth as likely in either frequent socialiser group, and almost half as likely in moderate socialisers, compared to infrequent socialisers. This supports other studies which suggest that barriers to social participation can include financial and psychological factors as well as physical limitations (Burholt & Scharf, 2014; Bowling & Stafford, 2007). This is an important consideration for studying those reporting infrequent social participation, as not all measures of social participation restriction consider economic factors (Wilkie et al., 2011; Magasi & Post, 2010).

In the Croezen study the prevalence of self-rated health, mental health and physical health measures (Croezen et al., 2009; Table 5, page 780) did not appear to differ between groups as much as was found in this study. For example, the proportion without mental health problems ranged from 74.6% to 91.3% in the Croezen study, compared to 50.5% to 80.8% in this study, although the difference in outcome measures employed may also influence cases identified. Incorporating frequency of activities thus appears to be useful in identifying groups with differing levels of health risk based upon social participation.

6.5.3 STRENGTHS AND LIMITATIONS

This analysis has a number of strengths: it examined a large sample drawn from a national population of older people (aged ≥50 years). There was a high response rate of 82%, and the sample used to identify social participation groups was broadly representative in terms of age and gender of the English older general population. The construct validity of the tools used to measure health and wellbeing has been demonstrated in other studies (Missinne et al., 2014; Steptoe et al., 2012; Demakakos et al., 2008; Banks et al., 2003). Several health factors were considered which may influence social participation and, in addition to examining each factor adjusted for age and gender, all factors were analysed simultaneously in a multivariable model to identify those with strong independent associations with the social participation groups.

A comprehensive range of social participation indicators was used to identify the different social participation groups, and they were selected from all available ELSA items using a theoretical model and systematic selection process. The LCA which was used to generate the social participation latent variable is data driven, and so identifies groups based upon variations found in the data rather than a priori researcher specifications. Previous studies examining social participation in ELSA have tended to measure social participation using simple one dimensional measures, such as group memberships (e.g. Pikhartova et al., 2014;Kouvonen et al., 2012), or summary scores of restricted activities (e.g. Wilkie et al., 2011;Hermsen et al, 2014) which neglect social participation differences arising independently of restriction. This study provides a multidimensional profile of social participation groups identified from a representative sample of English community-dwelling older people. The groups are distinguished in terms of the social roles and activities performed, rather than any restriction they encountered. Empirical evidence suggests that 'social participation' and 'social participation restriction' are not polar opposites in terms of their influence on health, but are two distinctive dimensions (Fiske et al., 2009;Parmelee et al., 2007).

A limitation of this analysis is the disproportionate amount of missing covariate data for the infrequent socialiser group (20.9% cf. 3.5%, 3.4% and 2.5% respectively), and these individuals were not included in the complete-case analysis which examined for the association between social participation groups and health factors. Infrequent socialisers were more likely to report poor mental and physical health, and this is consistent with other studies which have found those who are acutely unwell are most likely to be lost to attrition in longitudinal ageing studies (Volken, 2009;Korkeila et al., 2001), while people with milder, chronic health problems tend to be more diligent respondents in studies with a medical screening aspect (Mein et al., 2012). It is possible therefore that this analysis may have underestimated the associations with adverse health factors in infrequent socialisers. However, sensitivity analysis, including those with missing data, yielded similar associations between these groups and most sociodemographic and health factors.

As the study utilised pre-collected data (from ELSA) it was not possible to include all factors that have been suggested to influence associations between health and social participation, i.e. respondents were not asked about the duration, frequency, or causes of their pain. The data in this analysis was cross-sectional, and therefore cannot determine the direction or underlying causal mechanism of the associations examined. However, comparison of the univariable and multivariable models still enabled these associations to be examined more closely.

6.6 CHAPTER SUMMARY

In this analysis of a representative sample of community dwelling older people living in England, LCA identified four groups of older people, each with a distinctive social participation profile. These groups were; frequent socialisers with high levels of community engagement, frequent socialisers with low levels of community engagement, moderate socialisers and infrequent socialisers. More frequent social participation, in a wider range of activities, appears to be associated with better health and well-being in older people, independent of age and gender differences found between the identified groups.

CHAPTER SEVEN: THE ROLE OF SOCIAL PARTICIPATION IN DETERMINING MENTAL HEALTH

7.1 CHAPTER OVERVIEW

This chapter describes the quantitative study addressing Objective 4 of the thesis; to investigate the role of social participation in determining the association between musculoskeletal pain and subsequent mental health in older people.

7.1.1 INTRODUCTION

Poor mental health is a common problem in older people (Park & Unützer, 2011), and those with musculoskeletal pain have increased risk of deteriorating mental health and depression (Dominick, et al., 2012; Naylor, et al., 2012; Dawson, et al., 2005). Whilst the management of mental health conditions in older people is improving (i.e. identification and management), many continue to be affected (Park & Unützer, 2011;Barua et al., 2010). The National Institute for Health and Care Excellence (NICE) recently issued guidance highlighting the need to maintain and improve the mental wellbeing of older people in primary care (NICE, 2015). Social participation has been linked to better mental health (Chiao et al., 2011;Forsman et al., 2011;Golden et al., 2009), and suggested as a protective factor in older populations (Hong et al., 2009). However, the systematic literature search performed as part of this thesis identified that currently the precise role of social participation in determining which older people with musculoskeletal pain maintain mental health is unclear. This chapter reports the quantitative study performed to empirically test whether social participation fulfils the role of effect mediator, effect modifier and confounder of the association between musculoskeletal pain and mental health. A detailed, evidence-based rationale supporting the hypotheses tested in this study is provided in Section 3.2 of Chapter Three. The theoretical model used to develop the statistical models is described in more detail in Figure 2:4 of Chapter Two.

7.1.2 CHAPTER AIM AND OBJECTIVES

To address Objective 4 of the thesis, three distinct hypotheses were tested, each relating to one of the possible third variable roles social participation may fulfil (Figure 7:1):

a. Social participation is an effect mediator of the association between musculoskeletal pain and depressive symptoms in older people (role 1)

b. Social participation is an effect modifier of the association between musculoskeletal pain and depressive symptoms in older people (role 2)

c. Social participation is a confounding variable, distorting the true association between musculoskeletal pain and depressive symptoms in older people (role 3)

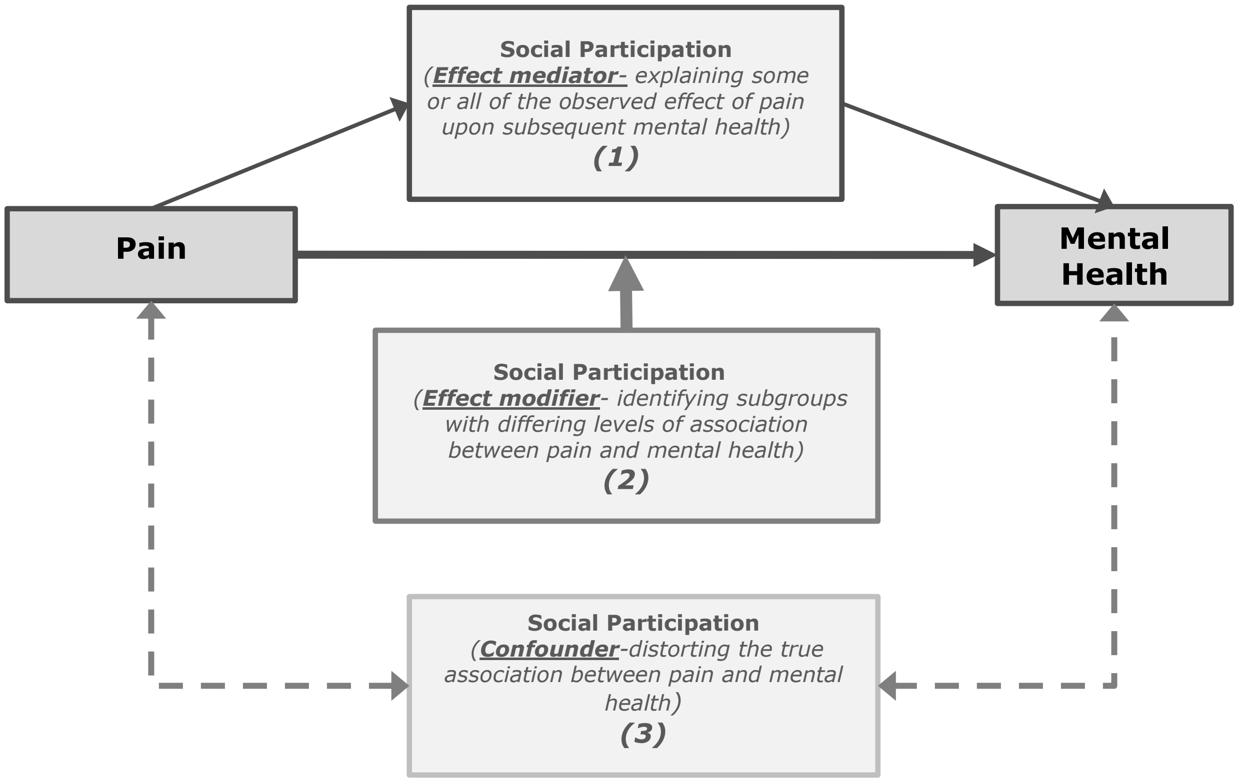


Figure 7:1 The proposed roles of social participation in the association of musculoskeletal pain on mental health in older people

7.2 METHODS

The study used health survey data collected from older people (aged ≥50 years) recruited as part of the English Longitudinal Study of Ageing (ELSA). Data were collected and coded into the appropriate variables as described in Chapter Five. Absence of depressive symptoms was used as an indicator of good mental health, based upon data collected using the 8-item version of the Center for Epidemiologic Studies on Depression (CES-D) questionnaire. A cut point of four or more depressive symptoms (Hamer, et al., 2009) was used to distinguish those with poor mental health (coded 0) from those with good mental health (coded 1). Details on how social participation and its health benefits were coded are provided in below. A summary of all included variables is provided in Section 7.2.2.

7.2.1 OPERATIONALISING SOCIAL PARTICIPATION AND THE DOWNSTREAM HEALTH BENEFITS IN THE EMPIRICAL ANALYSES

SOCIAL PARTICIPATION

Social participation characteristics were defined using the four distinct social participation groups identified in the latent class analysis reported in Chapter Six. Table 7:1 provides a reminder of the participant characteristics of each social participation profile identified and a summary of how the profiles were grouped for the empirical analyses. Effect modification and confounding were tested for using data collected from two time points; baseline (data collected: June 2004-July 2005) and two-year follow-up (data collected May 2006-August 2007). Testing for effect mediation required an additional time point, so also drew upon additional data collected at four-year follow-up (data collected: May 2008-July 2009). Social participation measured at baseline was used to test for effect modification and confounding. Due to the low proportion (n=38; 0.8%) of the sample being infrequent socialisers, the infrequent and moderate groups were combined to create a referent 'low' group who engaged in low or moderate social activities, to which the two frequent socialiser groups could be compared. There were thus three possible social participation categories; **Low**, **FreqLow** and **FreqHigh**.

For the mediation analysis, social participation data at two-year follow-up was also used. At baseline, the proportion of Infrequent socialisers at two-year follow-up was only 0.5% of the total mediation subsample (n=2654); infrequent and moderate social participation categories were again combined into a low social activity group to test for effect mediation. As effect mediation is based upon a change in the mediator variable explaining the observed outcome, a binary measure was created which coded those maintaining or moving into the FreqHigh or FreqLow social participation groups between baseline and two-year follow-up as '**Frequent socialisers**' (coded 1), and those who remained or moved into the Low referent group as '**Non-frequent socialisers**' (coded 0). In this way it was possible to test if social participation between baseline and two-year follow-up preceded a change in mental health status at four-year follow-up.

Table 7:1 Summary of the social participation groups

Social participation profile	Description of the profile characteristics	Moderation and confounding grouping	Mediation grouping
Frequent socialisers, high community engagement (FreqHigh)	Lives with their spouse/partner or alone. Sees children and friends weekly or more. Unlikely to be employed. Likely to participate in informal socialising. i.e. visiting museums, theatre shows and the cinema and eat out monthly or more. Takes holidays/ daytrips. Likely engage in formal socialising activities. i.e. being a member of charity, religious, educational, sporting or neighbourhood groups.	FreqHigh	Frequent socialisers *Those remaining in or moving into these groups at two-year follow-up*
Frequent socialisers, low community engagement (FreqLow)	Lives with their spouse/partner. Sees children and friends weekly or more. Likely to be in employment. Likely to participate in informal socialising. i.e. visiting museums, theatre shows and the cinema and eat out monthly or more. Takes holidays/ daytrips. Unlikely to do much formal socialising. May be a member of a social, sport or exercise related group.	FreqLow	
Moderate socialisers	Lives with a spouse/ partner or alone. Sees children and friends weekly or more. Unlikely to be employed. Does not go on recreational outings (e.g. theatre, museums). May take holidays/ daytrips. Unlikely to be a member of a social organisation or club.	Low *(Referent group)*	Non-frequent socialisers *(Referent group)* *Those remaining in or moving into these groups at two-year follow-up*
Infrequent socialisers	Lives alone or with those other than partner/spouse. Does not have, or do not regularly see, children and friends. Unlikely to be employed. Does not go on recreational outings (e.g. theatre, museums). Does not take holidays/ daytrips. Is not a member of any groups or organisations.		

PHYSICAL ACTIVITY

An individual's level of physical activity was identified using two items (Nunn et al., 2006); First, participants were asked how often they took part in three different types of leisure-time physical activity: vigorous, moderate and low intensity. The response options were: more than once a week, once a week, one to three times a month and hardly ever/never. Second, information on the current or last occupation of the ELSA respondent was used to categorise participants' occupational status as; not currently working, sedentary, standing occupation, does physical work or does heavy manual work. This summary variable conforms as closely as possible with the classification used in the Allied Dunbar Survey of Fitness (Fentem et al., 1994), and was categorised into one of four levels as done in previous studies (Hamer et al., 2009; Demakakos et al., 2008);

- High - heavy manual work or vigorous leisure activity more than once a week
- Moderate - does physical work; OR engages in moderate leisure-time activity more than once a week; OR engages in vigorous activity once a week to 1–3 times a month
- Low - standing occupation, engages in moderate leisure-time exercise once a week or less and no vigorous activity; OR engages in mild leisure-time activity at least 1–3 times a month, moderate once a week or less and no vigorous; OR has a sedentary or no occupation and engages in moderate leisure-time activity once a week or 1–3 times a month, with no vigorous activity
- Sedentary - not working or sedentary occupation, engages in mild exercise 1–3 times a month or less, with no moderate or vigorous activity

As the scores were count-level, a binary variable was created for analysis with low and sedentary physical activity levels coded as 0, and moderate or high physical activity levels coded as 1.

SOCIAL SUPPORT

Social support was defined as 'availability of support from social network contacts', and was operationalised as an index score capturing social embeddedness. Social embeddedness is an antecedent to social support (Langford, et al., 1997) and provided a proxy measure which was independent of items which contributed to the measures of social participation (e.g. contact with children/friends). The measure has been used in previous ELSA research (Steptoe et al., 2013), and combined responses to 12 questions capturing perceived social support from family/relatives, friends and spouse (as applicable) to yield a score ranging from 3 to 9. The score distribution for the sample was negatively skewed, so the scores were dichotomised to give a binary measure. Those scoring below the lowest quartile (score ≤8) were defined as having 'low' social support, and the remainder coded as having 'good' social support.

SENSE OF PURPOSE

A sense of purpose (also referred to in the literature as 'eudaimonic wellbeing'), is 'wellbeing gained from a sense of purpose, autonomy or meaning in life' (Ryff, et al., 2004). This was measured using items from the CASP-19 quality of life questionnaire (Hyde, et al., 2003). Questions covered the theoretical domains of control, autonomy and self-realization (e.g. 'I look forward to each day' and 'my life has meaning'). In total 15 CASP-

19 items were used to measure a sense of purpose, with the 4-item pleasure subscale, which captures hedonistic wellbeing, being excluded as has been done in previous studies (Gale et al., 2014;Steptoe et al., 2012b). This gave a possible score range of 1-45. The score distribution for the sample was negatively skewed, so was dichotomised to give a binary score. Tertiles were calculated (cut-offs were 28 and 34 at baseline), with those scoring below the lowest tertile defined as having poor sense of purpose and the others were categorised as having a good sense of purpose. The same cut-off value was used at two-year follow-up, (however a shift in the score distribution meant calculated tertile values were higher at 32 and 38 respectively over time because those who remained in the cohort were more likely to report a sense of purpose).

7.2.2 OVERVIEW OF VARIABLES USED IN THE MENTAL HEALTH ANALYSES

An overview of all variables used in the mental health analyses is provided in Table 7.2 below.

Table 7:2 Summary of variables used in the mental health analyses

Variable name	Data source	Categories
Musculoskeletal pain	Self-reported often troubled by pain	Yes (often troubles by pain)/ No (not often troubled by pain)
Social participation	Defined in terms of the profiles identified in the LCA reported in Chapter Six	See section 7.2.1.1 above
Mental health	8-item Center for Epidemiologic Studies on Depression (CES-D) questionnaire	Good (score ≤3)/ Poor (score ≥4)
Gender	Self-reported and UK census data	Male/ Female
Age (years)	Self-reported and UK census data	50-59 (ref), 60-69, 70-79, 80+
Economic adversity	Baseline total net non-pension wealth (self-reported)	Yes (lowest quintile)/ No (other quintiles)
Poor physical health	Self-rated health	Yes (fair/poor) / No (excellent/very good/good)
Chronic limiting illness	Two questions identifying troublesome long-standing illness, disability or infirmity that limited daily activities	Yes (long-standing illness which limits activities in some way)/ No (non-limiting or no chronic illness)
Physical activity	Derived variable based upon frequency and intensity of physical activity and occupational status.	High (moderate or high physical activity levels)/ Low (low and sedentary physical activity levels)
Social support	Operationalised as an index score of 12 items capturing social embeddedness	Good (Highest two tertiles)/ Low (Lowest tertile)
A sense of purpose	15 items from the CASP-19 quality of life questionnaire	Good (Highest two tertiles)/ Poor (Lowest tertile)

7.3 STATISTICAL ANALYSIS

7.3.1 PARTICIPANT CHARACTERISTICS

The sampling frame for this study was adults aged 50 years and over who provided complete data for the respective analysis. For testing the role of social participation as an effect modifier and a confounder, the analytical sample was those who responded with complete musculoskeletal pain, mental health, social participation and covariate data at baseline as well as mental health data at two-year follow-up. However, as data from an additional time point (four-year follow-up) was required to test for effect mediation, this analysis was performed on a subsample of participants who provided additional social participation, physical activity, social support and sense of purpose data at two-year follow-up and mental health outcome data at four-year follow-up. Figure 7:6 later in the chapter illustrates participant flow.

To examine the likelihood of response bias differences between the target population and the respective analytical sample, comparisons were made in terms of the age and gender distribution of the moderation/confounder sample and the mediation subsample with that of nationally representative census data collected from those aged ≥50 years. This was performed using cross-tabulations. For each baseline variable, comparisons were then made between the responses of the analytical samples and all ELSA respondents who provided a response to that respective variable to see if similar trends were seen in the analytical samples as in all those available in the ELSA dataset. This provided further indication of potential response bias. Then, within the moderation/confounding sample and mediation subsample respectively, differences between social participation groups were examined using chi-square statistics and Bonferroni adjusted p-values. Variance inflation factors (VIFs) were used to examine for collinearity between independent variables in the logistic regression analyses. Descriptive analyses were performed in IBM SPSS 21.

7.3.2 TESTING THE ROLE OF EFFECT MEDIATOR

Path analysis, using logistic regression modelling and the product of coefficients approach to mediation, was used to test whether social participation was an effect mediator of the association between baseline musculoskeletal pain and good mental health at follow-up (described in more detail in Chapter Three). The model was specified and estimated in MPlus version 7.2 (Muthén & Muthén, 2015). Maximum likelihood (ML) estimation was used as it is recommended when modelling binary outcomes in regression models because ordinary least squares estimation is not capable of producing minimum variance unbiased estimators for the actual parameters in logistic regression (Muthén & Muthén, 2015;Czepiel, 2002). Bootstrapped 95% confidence intervals were calculated for all coefficient estimates (with 10000 draws), as they allow for asymmetrically distributed parameter estimations to be accommodated for. The regression coefficients were calculated as beta coefficients (β) with standard errors (SE), and then converted to odds ratios (ORs) with 95% confidence intervals (95% CIs) for easier interpretation when comparing between models and summarising the extent to which social participation fulfilled the role of effect mediator. Bootstrapping methods (10000 draws) were used to calculate the 95% CIs for the total, indirect, and direct effect estimates. Effect mediation was tested for first using an unadjusted model (Model 1), and then sequentially adjusted in subsequent models for; sociodemographic factors (Model 2), health factors (Model 3) and baseline mental health (Model 4), to examine to what extent any effect mediation by social participation remained (Figure 7:2).

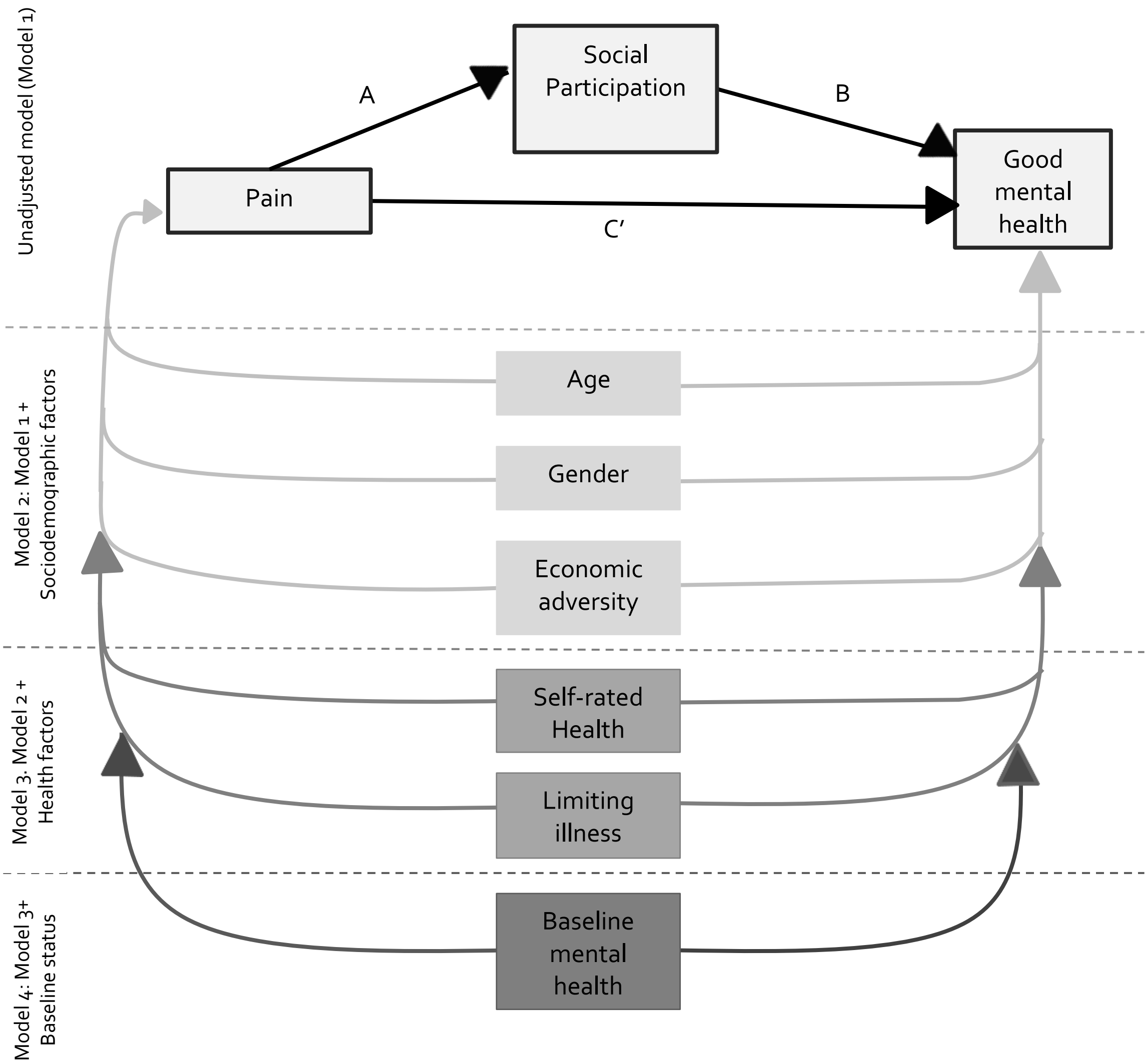


Figure 7:2 The series of sequentially adjusted models used to test for effect mediation

Finally, to further understanding of why social participation is associated with maintaining mental and physical health in older people, this thesis examined to what extent three constructs, identified as ways in which social participation influences subsequent health, (i.e. physical activity, social support and a sense of purpose), were associated with maintaining subsequent good mental and physical health. These three factors were entered as multiple, parallel mediators into the fully adjusted model to test for effect mediation, and whether any mediating effect of social participation persisted after the mediating effect of these factors was accounted for in the model.

7.3.3 TESTING THE ROLE OF EFFECT MODIFIER

The extent to which social participation fulfilled the role of effect modifier in determining which older people with musculoskeletal pain maintain good mental health was examined in two phases. First, social participation (as two dummy variables 'FreqHigh' and 'FreqLow') was included in a multivariable model of the association with good mental health at 2-year follow-up. Then an interaction term between each social participation variable and musculoskeletal pain was included. Secondly, if a significant interaction term was identified, multigroup analysis was performed to explore the association between musculoskeletal pain and mental health, including sociodemographic and other health factors, for each social participation subgroup. Then sociodemographic covariates which had been identified as putative confounders in the underlying theoretical model (i.e. age, gender and economic adversity) were added to test whether any associations of musculoskeletal pain and social participation persisted. The underlying analytical models are illustrated in Figure 7:3.

Results were calculated as beta coefficients (β) with standard errors (SE), and then converted to odds ratios (ORs) with 95% confidence intervals (95% CIs) for easier interpretation when comparing between models and summarising the extent to which social participation fulfilled the role of effect modifier. In all models bootstrapping methods (10000 draws) were used to calculate the 95% confidence intervals for variable coefficients.

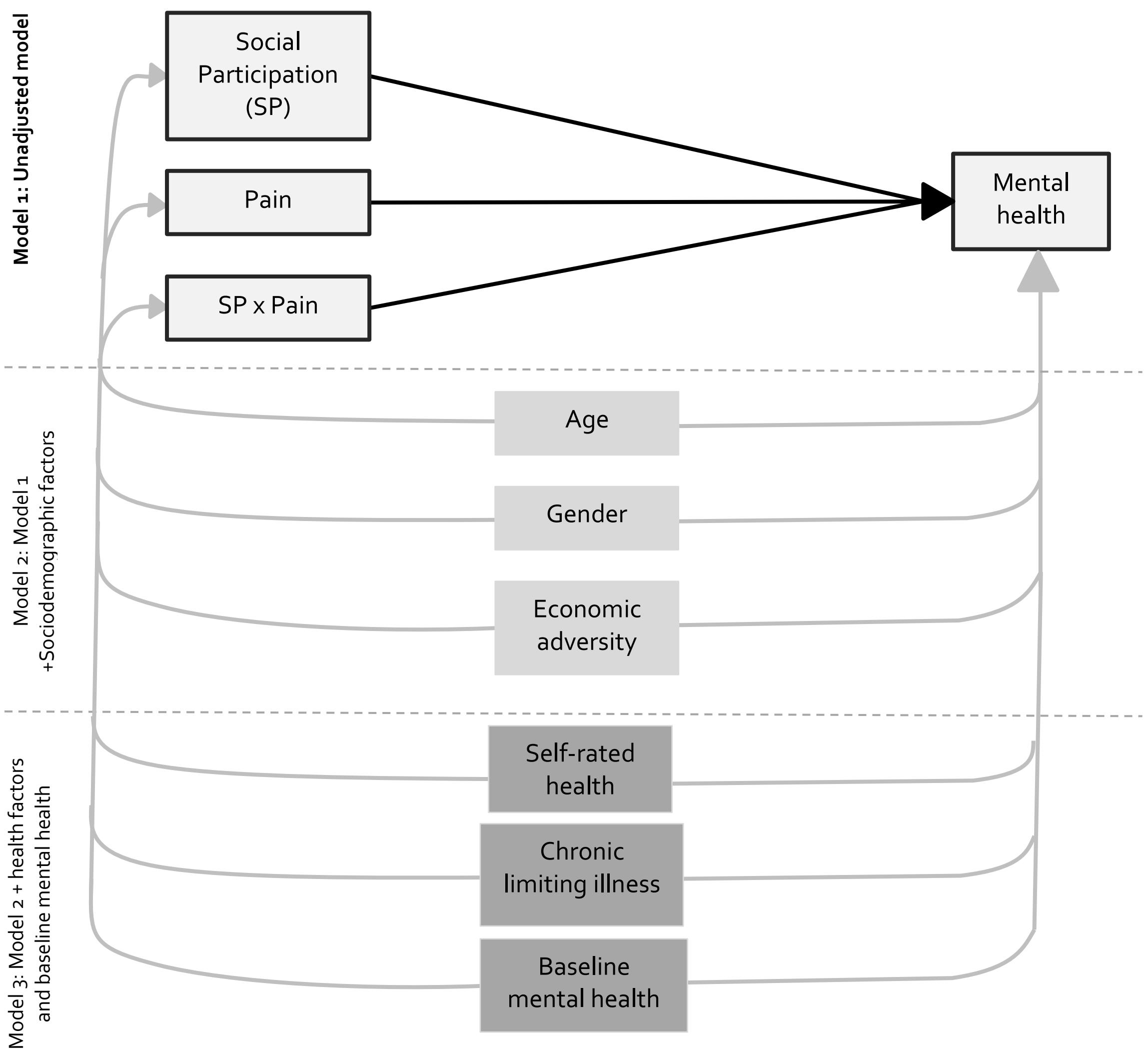


Figure 7:3 The series of sequentially adjusted models used to test for effect modification

A significant statistical interaction was identified, therefore a multigroup analysis was performed to explore the association between baseline musculoskeletal pain and mental health within the context of a specific social participation subgroup. A single fully adjusted model (Figure 7:4) was run which included all the covariates of Model 3 (i.e. age, gender, economic adversity, self-rated health, chronic limiting illness and baseline mental health).

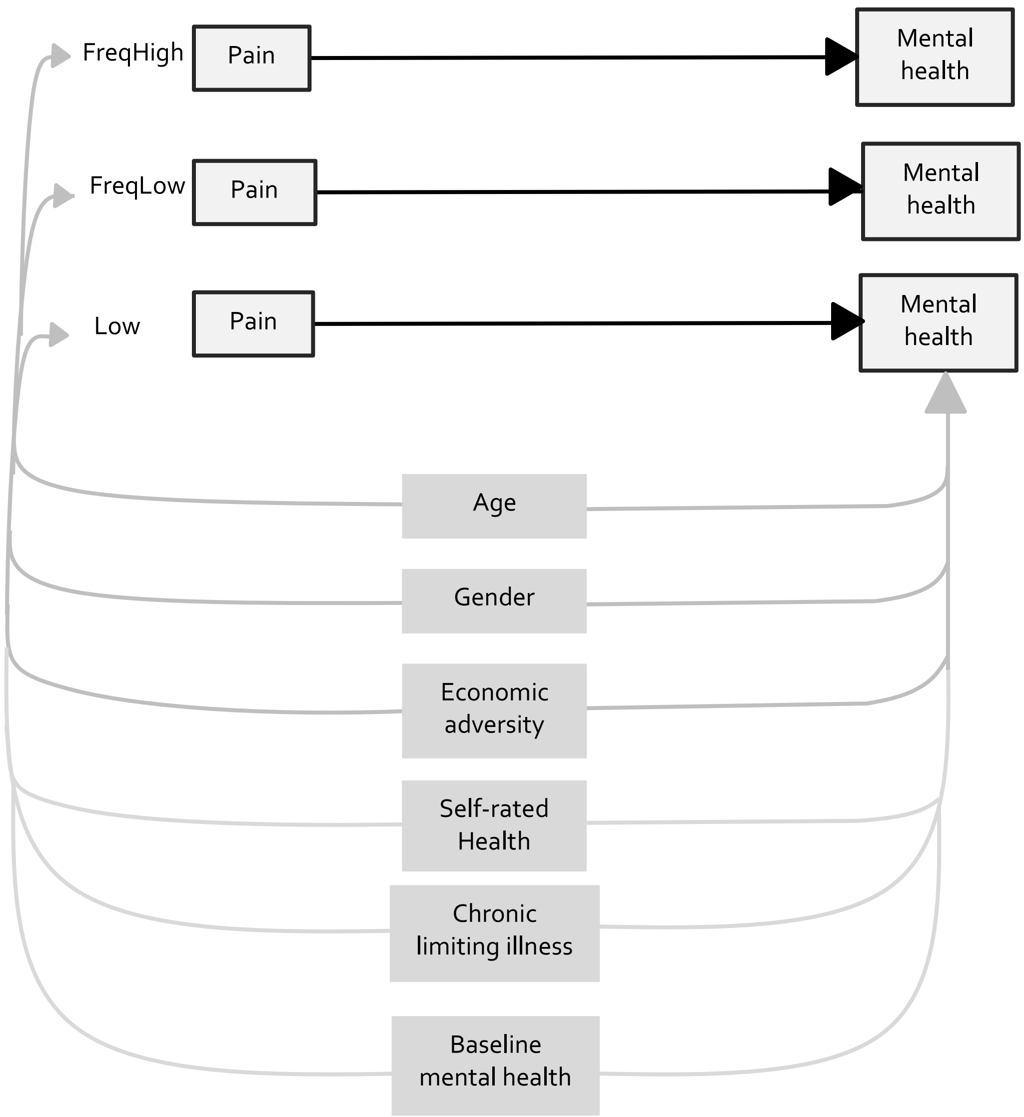


Figure 7:4 The multivariable model used to test for effect modification across individual social participation groups

7.3.4 TESTING THE ROLE OF CONFOUNDER

The final third variable role, that of confounder, was tested for using a series of multivariable regression models starting with the total effect of baseline musculoskeletal pain on mental health. Next social participation was added as a covariate, and the magnitude of confounding attributed to social participation quantified by calculating the difference in odds ratios between the initial and adjusted effect size of baseline musculoskeletal pain on mental health, and dividing it by the adjusted total effect of musculoskeletal pain on mental health. To test whether any confounding effect persisted independently of other putative confounders, the two models were then re-run with the sociodemographic, health and baseline mental health status covariates included; first with social participation removed and then with social participation added back into the model. The magnitude of any change in the effect of musculoskeletal pain on mental health between the pairs of models were then examined to assess the extent of confounding. In all models bootstrapping methods (10000 draws) were used to calculate the 95% confidence intervals for the musculoskeletal pain coefficient. The results were calculated as beta coefficients (β) with standard errors (SE), and then the association between baseline musculoskeletal pain and good mental health converted to odds ratios (ORs) with 95% confidence intervals (95% CIs) for easier interpretation when comparing models with and without statistical adjustment for confounding by social participation. As the magnitude of confounding is indicated by the change in the magnitude and significance of an association, the odds ratios for other covariates adjusted for in the model were not formally examined.

7.3.5 SENSITIVITY ANALYSES

MISSING DATA BIAS

In this study missing data was deemed to be missing not at random, as those with poor health and/or infrequent social participation were most likely to be excluded from the analytical samples due to missing data (differences are reported in Section 8.6). To examine for potential bias due to missing data, sensitivity analyses were performed for each initial unadjusted model, and the final model of each analysis sequence, in which some of the variables had missing values, using FIML estimation. The association estimates were then compared to the complete case analyses. The incomplete case dataset consisted of all participants assigned a baseline social participation group in the earlier LCA (n= 7266). Both the complete case and incomplete case analysis results for the initial, unadjusted model and final fully-adjusted model are reported in the findings for each of the three third variable roles.

RECIPROCAL CAUSALITY

As poor mental health (i.e. symptoms of anxiety and depression) has been found to predict subsequent social participation restriction in older people (Wilkie, et al., 2016), further sensitivity analyses were performed to examine to what extent the relationship between social participation and good mental health was recipriocal. To test the extent of reciprocity between social participation and mental health, an unadjusted, autoregressive cross-lagged panel model was used to simultaneously address reciprocal influences between social participation and mental health outcomes at baseline and two-year follow-up using the mediation subsample (Figure 7:5).

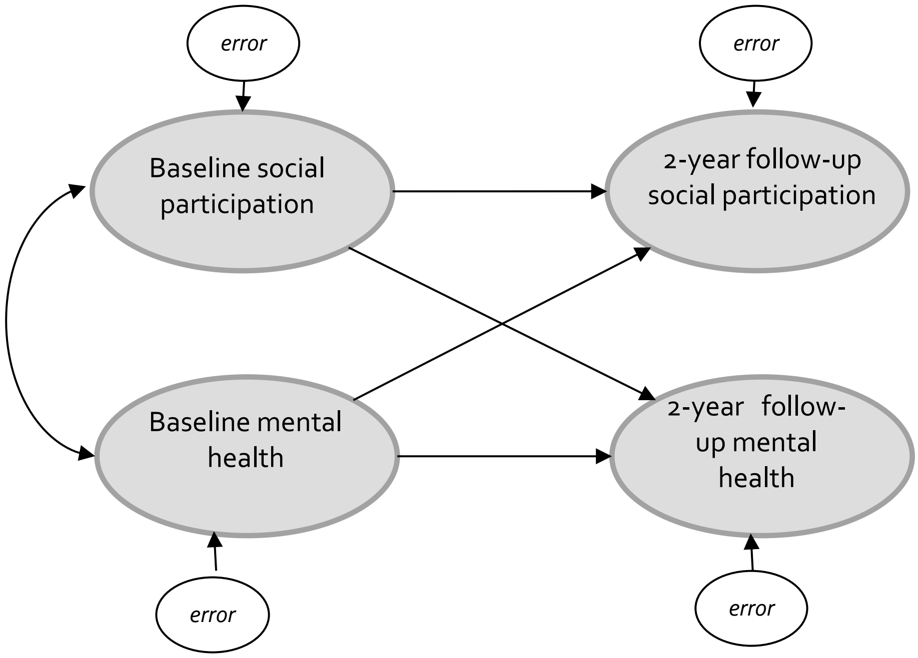


Figure 7:5 Unadjusted, autoregressive cross-lagged panel model using data from baseline and 2-year follow-up to test for a reciprocal effect between social participation and mental health

INFLUENCE OF SOCIAL PARTICIPATION CUT-OFF POINT

The dichotomisation of the social participation variable for the mediation analyses was conceptually driven, in that it allowed those engaging in frequent social participation to be compared to those with infrequent or moderate social participation habits. A sensitivity analysis was performed to test whether the cut-off point for social participation affected the study findings. This was done by rerunning the unadjusted mediation model using two alternate methods of defining social participation. The first coded FreqHigh socialisers as 1, and all others (i.e. infrequent, moderate and FreqLow) together as 0. The second method coded infrequent socialisers as 0, and all other socialisers as 1.

MUSCULOSKELETAL PAIN SEVERITY

It is possible that musculoskeletal pain severity might influence the strength of association between musculoskeletal pain and social participation and good mental health respectively. A sensitivity analysis was performed to test whether pain severity (rated as mild, moderate or severe by participants) influenced the study findings for effect mediation. First the distribution of mild, moderate and severe pain was examined by social participation category, and then the fully adjusted mediation model was rerun using only those who reported moderate or severe pain (coded 1) and those reporting no pain (coded 0). Participants reporting mild pain were excluded from this sensitivity analysis.

7.4 RESULTS: ANALYTICAL SAMPLES

7.4.1 DETERMINING THE ANALYTICAL SAMPLES

Of the 9432 individuals aged ≥50 years who returned a questionnaire at baseline, 261 participants were aged <50 years so excluded (Figure 7:6). Of those, 5798 (79.8%) provided complete mental health outcome data at two-year follow-up. A further 1051 participants were excluded due to having missing covariate data (61.7%; n=648, of which were excluded as they had incomplete wealth data) leaving 4747 (51.8% of the 9171 eligible respondents) for the analyses examining effect moderation and confounding. Of the 4747 participants, 2654 (55.9%) provided complete mental health data at 4-year follow-up and social participation, a sense of purpose, physical activity and social support data at 2-year follow-up, and were the sample for the mediation analyses.

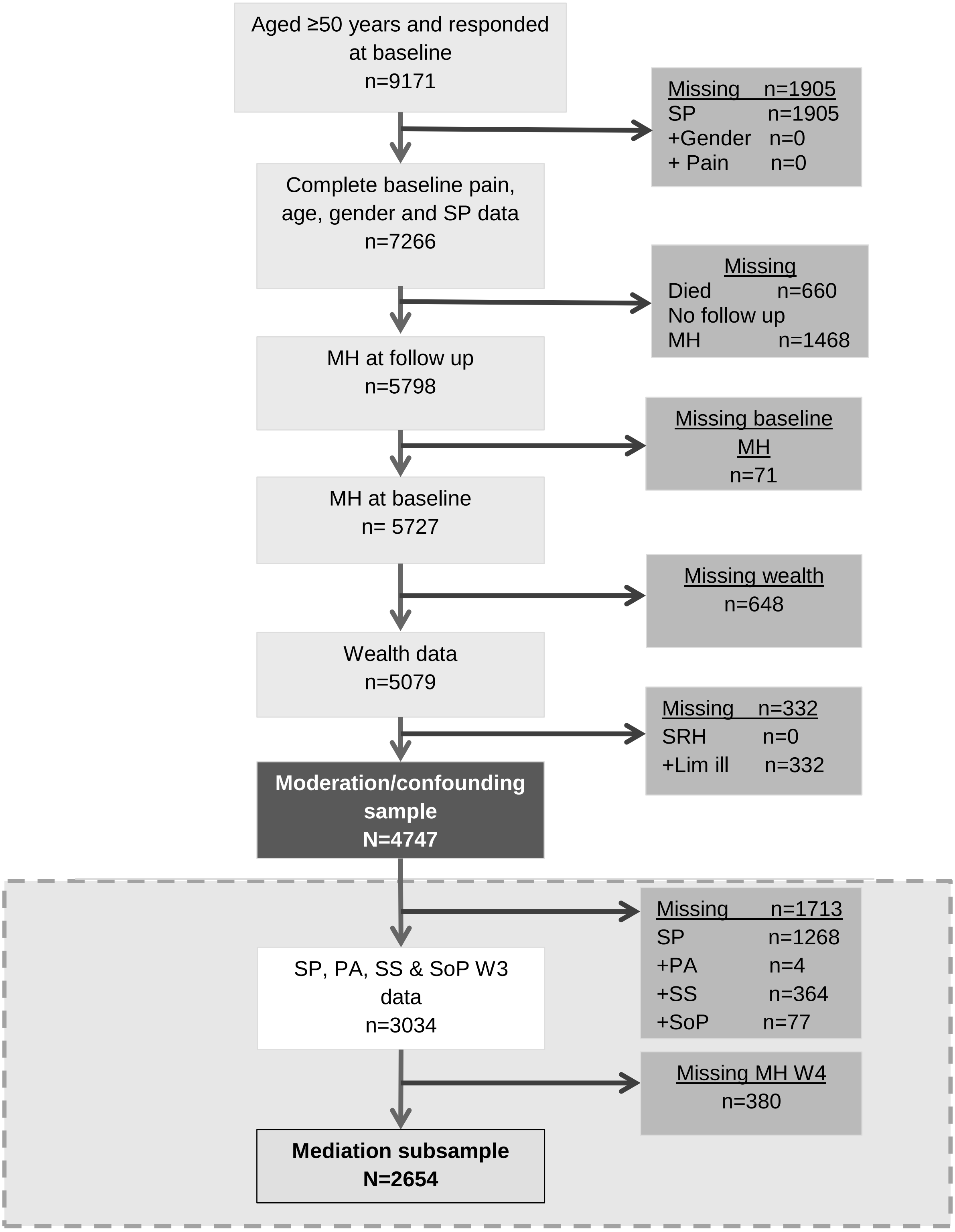


Figure 7:6 Flow diagram showing number of participants in the moderation sample and mediation subsample[1]

[1] SP= social participation, MH= mental health, SRH= self-rated health, Lim ill= limiting chronic illness, PA= physical activity, SS= social support, SoP = sense of purpose (eudaimonic wellbeing)

7.4.2 COMPARISON BETWEEN MODERATOR/CONFOUNDING AND MEDIATION SAMPLES AND THE ENGLISH GENERAL POPULATION

Comparisons between census data and the sample participants in the moderation/confounding sample (henceforth referred to as the 'moderation sample') and the mediation subsample are shown in Table 7:3. From observation, compared to the age and gender structure of the English population aged ≥50 years, the proportion of the men and women aged ≥80 years was lower in the moderation sample (6.8%) and was lowest in the mediation subsample (4.4%). Compared to the English population (33.7%), there were more women aged 50-59 and 60-69 years in the moderation sample (39.7%), and mediation subsample (43.6%).

Table 7:3 The age and gender structure of the English Population, the moderation sample and the mediation subsample

	English Population[10]		Moderation sample		Mediation subsample	
	Male	Female	Male	Female	Male	Female
50-59	17.6%	17.9%	16.3%	20.8%	17.7%	23.5%
60-69	15.1%	15.8%	16.5%	18.9%	16.2%	20.1%
70-79	9.5%	10.8%	9.6%	11.0%	8.7%	9.4%
80+	5.1%	8.3%	2.8%	4.0%	1.8%	2.6%
Total	47.2%	52.8%	45.3%	54.7%	44.4%	55.6%

[10] ONS Population estimates tool (2013 estimate)
http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/2013/index.html
Proportions shown are calculated using the total number of men and women in that group as a denominator

7.4.3 CHARACTERISTICS OF THE MODERATION/CONFOUNDING SAMPLE

The characteristics of ELSA respondents (providing complete data for that respective variable) in the moderation sample and mediation subsample are provided in Table 7:4. The moderation sample was slightly younger (72.5% aged <70 years cf. 62.0% of overall ELSA respondents) and reported higher and more varied wealth (mean £309,000 [SD 438,000] cf. £265,000 [SD 393,000]) than ELSA respondents. Musculoskeletal pain prevalence was similar in both the moderation sample (37.2%) and ELSA respondents (37.1%), and the groups had a similar distribution of men and women (proportion of females were; ELSA:56.3%, moderation sample 54.7%, and mediation subsample 55.6%). The moderation sample had slightly better overall health than the ELSA respondents, with a higher proportion reporting good self-rated health (78.9% cf. 72.2%) and good mental health (73.8% cf. 69.0%), and fewer reporting limiting chronic illness (30.8% cf. 35.4%).

Table 7:4 The baseline characteristics of the moderation sample, the mediation subsample and the overall ELSA sample who provided the respective data

		ELSA Respondents		Moderation sample		Mediation subsample	
Total number of older people		9432		4747		2654	
Gender (female)		5307	56.3%	2595	54.7%	1475	55.6%
Age (years)	50-59	2925	31.9%	1761	37.1%	1094	41.2%
	60-69	2920	31.8%	1681	35.4%	963	36.3%
	70-79	2203	24.0%	978	20.6%	480	18.1%
	80+	1123	12.2%	327	6.9%	117	4.4%
Ethnicity (Caucasian)*		9192	97.5%	4687	98.7%	2628	99.0%
Wealth £1000 (mean; sd)	[m=752]	265	393	309	438	350	502
Musculoskeletal pain		3505	37.2%	1659	37.1%	863	32.5%
Good self-rated health	[m=138]	6711	72.2%	3744	78.9%	2202	83.0%
Limiting chronic illness	[m=3]	3341	35.4%	1463	30.8%	741	27.9%
Good mental health	[m=275]	6321	69.0%	3503	73.8%	2051	77.3%
Social factors:							
Lives alone	[m=207]	2270	24.1%	1103	23.2%	549	20.7%
Weekly contact with others	[m=292]	6559	69.5%	3848	81.1%	2201	82.9%
Group memberships ≥2	[m=594]	2777	29.4%	1864	39.3%	1154	43.5%

Values are given as proportions (n), or mean (standard deviation) as appropriate. The proportion with missing data for ELSA respondents is given in square brackets [m=], only Ethnicity was missing for either of the other two groups (moderation sample m=3)
Contact with others considers social network members defined as friends, relatives and/or family
Group memberships capture membership in one or more of seven distinct group types; social, political, neighbourhood, educational & art, religious, sport and charitable

The characteristics of each social participation group within the moderation sample were examined and are reported in Table 7:4. The proportion of people aged ≥70 was higher in the Low socialiser group (38.6%) than the FreqLow socialisers (14.0%) and FreqHigh socialisers (27.7%). The prevalence of economic adversity in Low socialisers was over three times as high as in the other two groups (35.2% cf. 9.2% and 9.4% in the FreqLow and FreqHigh groups respectively). The Low socialiser group had a higher prevalence of musculoskeletal pain (43.8% cf. 27.6% and 30.2% respectively), and lower prevalence of good mental health (reported by 63.6% cf. 80.8% and 81.2% respectively). Limiting chronic illness was approximately twice as prevalent in Low socialisers than either of the other two frequent social participation groups (42.5% cf. 19.0% and 22.7% respectively). At two-year follow up, good mental health was reported by 1250 (63.9%) of Low socialisers, 1355 (82.9%) FreqLow and 944 (81.7%) FreqHigh socialisers. Comparison across each social participation group for those with and without musculoskeletal pain found the prevalence of good mental health at two-year follow-up to be 48.4% in Low socialisers with musculoskeletal pain compared to 76.0% in Low socialisers without musculoskeletal pain. In FreqHigh and FreqLow groups these prevalences were 73.9% cf. 86.2% and 71.3% cf. 86.3% respectively.

Table 7:5 The baseline characteristics of each social participation group in the moderation sample (n=4747)

		Low socialisers		FreqLow socialisers		FreqHigh socialisers		p-value
Total number		1957		1635		1155		-
Gender (female)		1026_a	52.4%	852_a	52.1%	717_b	62.1%	p<.000
Age (years)	50-59	545_a	27.8%	874_b	53.5%	342_a	29.6%	
	60-69	656_a	33.5%	532_a	32.5%	493_b	42.7%	
	70-79	527_a	26.9%	190_b	11.6%	261_c	22.6%	
	80+	229_a	11.7%	39_b	2.4%	59_c	5.1%	p<.000
Ethnicity (Caucasian)*		1926_a	98.5%	1618_a	99.0%	1143_a	99.0%	p=.325
Economic adversity		689_a	35.2%	151_b	9.2%	109_b	9.4%	p<.000
Musculoskeletal pain		858_a	43.8%	452_b	27.6%	349_b	30.2%	p<.000
Good mental health		1244_a	63.6%	1321_b	80.8%	938_b	81.2%	p<.000
Limiting chronic illness		832_a	42.5%	311_b	19.0%	320_c	22.7%	p<.000
Poor self-rated health		677_a	34.6%	486_b	11.4%	140_b	12.1%	p<.000

$_{a,b,c}$ *Subscript letters distinguish groups with significantly different proportions (p<.05)*

7.4.4 CHARACTERISTICS OF THE MEDIATION SUBSAMPLE

Compared to ELSA respondents overall, the mediation sample were younger, reported greater wealth, were more likely to be frequent socialisers and reported better health (Table 7:4). They reported less musculoskeletal pain (32.5% cf. 37.2%), lower prevalence of limiting chronic illness (27.9% cf. 35.4%), and had approximately a 10% higher prevalence of both good mental health and good self-rated health then ELSA respondents overall. The proportion of women was similar (55.6% cf. 56.3%) in the mediation subsample compared to ELSA respondents overall. Comparison of the social characteristics showed that the mediation subsample was a little less likely to live alone, and over 10% more likely to have weekly contact with others (82.9% cf. 69.5%), with almost 50% of the older people in the mediation subsample being members of ≥2 social groups, compared to approximately 40% of the moderation sample and approximately 30% of ELSA respondents overall.

Participants in the mediation subsample were categorised as either: i) 'Infrequent socialisers'- low socialisers at baseline and two-year follow-up, or reducing to low at two-year follow-up, or ii) 'frequent socialisers'- those consistently frequent or increasing to frequent socialisers at baseline and follow-up. The baseline characteristics of the two groups are described in (Table 7:5) below. At four-year follow up, good mental health was reported by 719 (80.6%) of Low socialisers, 937 (93.8%) FreqLow and 709 (92.9%) FreqHigh socialisers.

Table 7:6 The baseline characteristics of each social participation group in the mediation sample (n=2654)

		Infrequent socialisers		Frequent socialisers		p-value
Total number		752		1902		-
Gender (female)		415	55.2%	1060	55.7%	p=.758
Age (years)	50-59	204	27.1%	890	46.7%	
	60-69	244	32.4%	719	37.8%	
	70-79	226	30.1%	254	13.4%	
	80+	78	10.4%	39	2.1%	p<.000
Ethnicity (Caucasian)		745	99.1%	1883	99.0%	p=.844
Economic adversity		244	32.4%	167	8.8%	p<.000
Musculoskeletal pain		333	44.3%	530	27.9%	p<.000
Good self-rated health		499	66.4%	1703	89.5%	p<.000
Limiting chronic illness		328	43.6%	413	21.7%	p<.000
Good mental health		491	65.3%	1560	82.0%	p<.000
Sense of purpose (good)		492	65.4%	1656	87.1%	p<.000
Physical activity (high)		482	64.1%	1644	86.4%	p<.000
Social support (good)		449	59.7%	1325	69.7%	p<.000

** n=1 missing ethnicity data in this group*

In the mediation subsample, compared to non-frequent socialisers those who were frequent socialisers were younger, with very few aged 80 and over (2.1% cf. 10.4%) and almost half (46.7%) aged 50-59 years, compared to approximately a quarter (27.1%) of non-frequent socialisers. There was no significant difference in the proportion of Caucasian people (both 99%; p=.744), however frequent socialisers were less likely to be categorised as facing economic adversity (8.8% cf. 32.4%). Frequent socialisers were less likely to report musculoskeletal pain at baseline (27.7% cf. 44.3%), and the prevalence of chronic illness was almost half that of the non-frequent socialisers (21.7% cf. 43.6%). Compared to the referent group in the moderation sample, the health of the referent group in the mediation sample (non-frequent socialisers) was similar in terms of prevalence of baseline musculoskeletal pain (44.3% in the mediation subsample referent group compared to 43.8% in the moderation sample), good self-rated health (66.4% cf. 65.4%) and good mental health (65.3% cf. 63.6%).

7.4.5 CHANGE IN MENTAL HEALTH BETWEEN BASELINE AND FINAL FOLLOW-UP FOR THE MODERATION SAMPLE AND MEDIATION SUBSAMPLE

Approximately one in four participants in the moderation sample, and one in five of the mediation subsample, had improved or worse mental health between baseline and the respective final follow-up (i.e. 2-year follow-up for the moderation/confounding sample and 4-year follow-up for the mediation subsample). At baseline 73.8% of the moderation sample, and 77.3% of the mediation subsample reported good mental health. Overall participants with good mental health at baseline were highly likely to have maintained good mental health at the respective follow-up (Tables 7:7 and 7.8); 84.8% maintained good mental health at 2-year follow-up, and 94.1% of those who remained in the mediation subsample did so. Approximately half of those who reported poor mental health at baseline then reported good mental health at 2-year follow-up (46.4%), and almost three quarters of the mediation subsample who reported poor mental health at baseline reported improved mental health at 4-year follow-up (72.3%). Thus while mental health was most likely to remain consistent across waves, between baseline and 2-year follow-up a similar proportion reported an improvement in mental health as reported a reduction. However, for the mediation subsample between baseline and 4-year follow-up, the proportion of respondents whose mental health improved was 3.6 times the proportion whose mental health declined (436 cf. 122).

Table 7:7 Change in mental health status between baseline and outcome measurement for the moderation sample

N=4747	Moderation sample	
	Poor health (2yr)	Good health (2yr)
Poor health (baseline)	666 (14.0%)	578 (12.2%)
Good health (baseline)	532 (11.2%)	2971 (62.6%)

Table 7:8 Change in mental health status between baseline and outcome measurement for the mediation subsample

N=2654	Mediation sample	
	Poor health (4yr)	Good health (4yr)
Poor health (baseline)	167 (6.3%)	436 (16.4%)
Good health (baseline)	122 (4.6%)	1929 (72.7%)

7.5 RESULTS: THE ROLE OF SOCIAL PARTICIPATION

7.5.1 SOCIAL PARTICIPATION AS AN EFFECT MEDIATOR

EXAMINING THE EXTENT TO WHICH SOCIAL PARTICIPATION IS AN EFFECT MEDIATOR

In the initial, unadjusted effect mediation analysis, frequent social participation was a weak, but significant effect mediator of the association between baseline musculoskeletal pain and mental health four years later (Figure 7:7; p<.001). Older people with musculoskeletal pain were over three times less likely to report good mental health at four-year follow-up (OR:0.30; 95%CI:0.23,0.38) than those without baseline musculoskeletal pain. When decomposed into direct and indirect effects, there was a significant indirect effect (p<.001), and the odds ratio associated with reporting good mental health between those with and without baseline musculoskeletal pain reduced slightly (OR:0.34; 95%CI:0.27,0.45). In the unadjusted decomposed model, the odds of those with baseline musculoskeletal pain being a frequent socialiser were half that observed in those without baseline musculoskeletal pain (OR:0.49;95%CI:0.41,0.58), however those who did maintain frequent social participation had over three times the odds of good mental health at four-year follow-up than that of infrequent socialisers (OR:3.15;95%CI:2.44,4.08). The natural indirect effect, given when musculoskeletal pain and social participation were reverse coded, suggested that those with baseline musculoskeletal pain who maintained frequent social participation had over twice the odds of reporting good mental health at four-year follow-up than those with musculoskeletal pain who reported infrequent social participation (OR: 2.29;95% CI: 1.77,3.09).

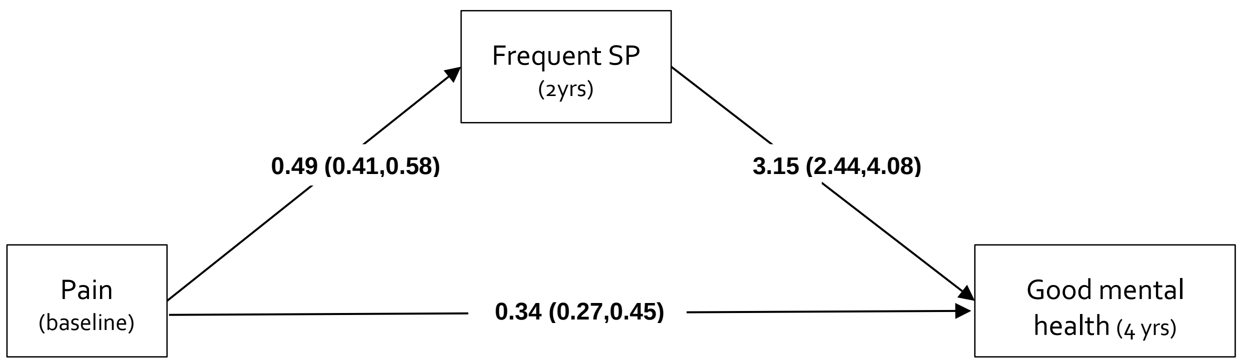


Figure 7:7 Path diagram illustrating the direct effect and causal paths linking musculoskeletal pain and good mental health. Results reported as odds ratio and 95% CIs

The total, direct and indirect path results for the series of sequentially adjusted models are provided in Table 7:9 below. In Model 2, after adjustment for age, gender and economic adversity, frequent social participation remained a significant, but weak mediator. However, once chronic limiting illness and self-rated health were added (Model 3), the indirect path between baseline musculoskeletal pain and frequent social participation was attenuated to non-significance (p=.289), and remained so with the addition of baseline mental health (Model 4). In the fully adjusted model, there was an insignificant trend towards better mental health in frequent socialisers with musculoskeletal pain compared to that of non-frequent socialisers with musculoskeletal pain (OR:0.91, 95% CI: 0.74, 1.07).

The 'a path' between baseline musculoskeletal pain and frequent social participation became insignificant once differences in self-rated health and limiting chronic illness were accounted for, suggesting functional limitation and perceived health impact associated with musculoskeletal pain are associated with the frequency of social participation. However, the 'b path' was large and significant in all models showing frequent social participation to be a strong predictor of maintaining mental health in older people independently of baseline musculoskeletal pain. The odds ratios for the direct effect pathway in the fully adjusted model remain significantly lower than 1.0. This indicates that musculoskeletal pain remains a significant risk factor of subsequent mental health in older people, even if social participation is accounted for.

Of the other covariates included in the final, fully adjusted decomposed model, baseline mental health was the most influential, with good mental health at baseline associated with over three times the odds of reporting good mental health at 4-year follow-up

(OR:3.27, 95%CI:2.43,4.38). Economic adversity and age were not significantly associated with mental health at 4-year follow-up (at $p<.05$ level). However, female gender (OR:0.43; 95%CI;0.39,0.59), limiting chronic illness (OR:0.64; 95%CI:0.47,0.72) and poor self-rated health (OR:0.50; 95%CI:0.36,0.90) were all negatively, and significantly, associated with maintaining mental health at 4-year follow-up.

Table 7:9 The total, direct and indirect effects of the association between musculoskeletal pain and mental health via social participation (SP) for the series of sequentially adjusted models (N=2654)

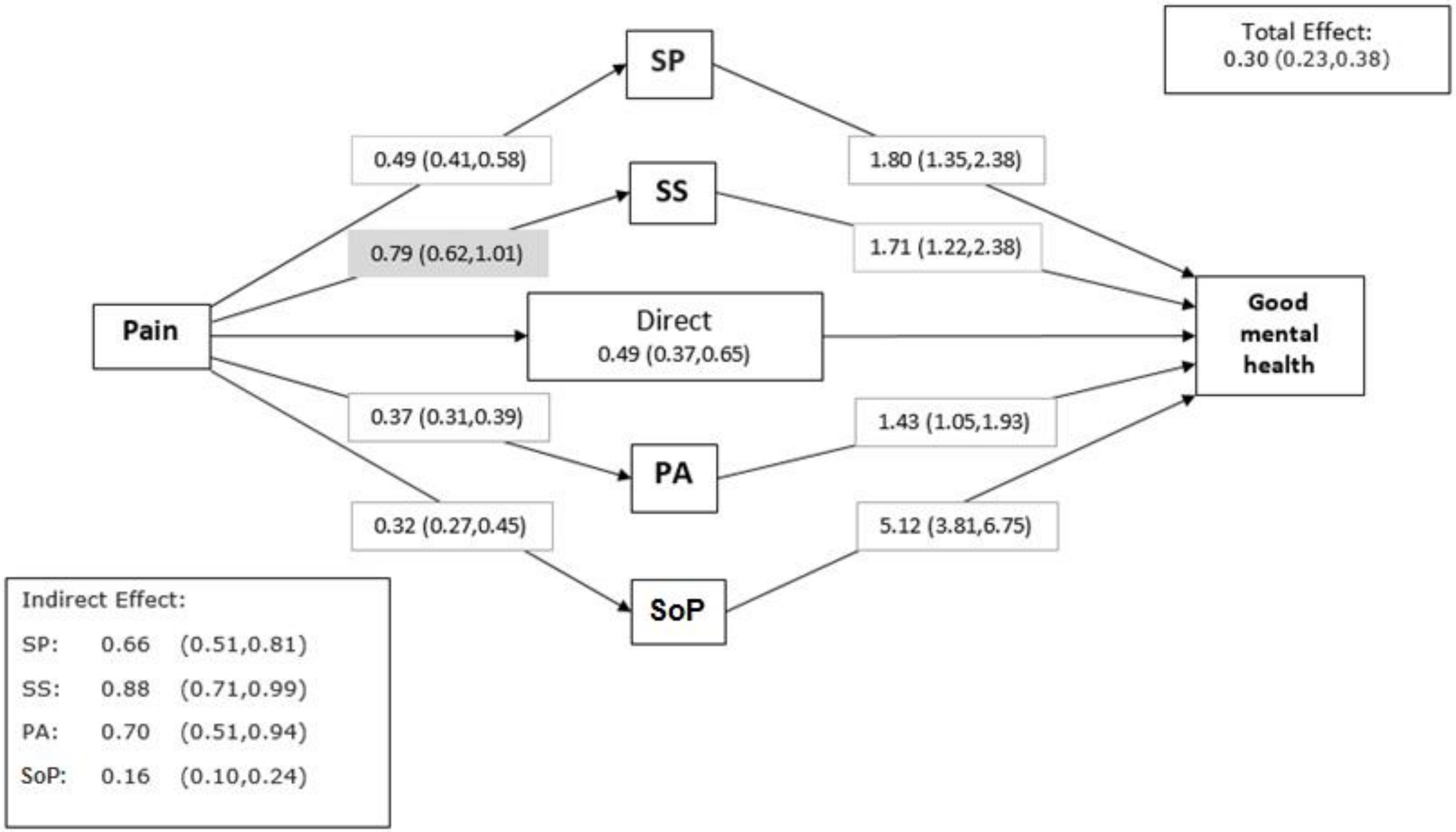
Path	Model 1		Model 2		Model 3		Model 4	
	Total Effect (c path)	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*
Musculoskeletal pain to Mental health	0.30 (0.23,0.38)	0.34 (0.27,0.45)	0.34 (0.26,0.44)	0.38 (0.29,0.49)	0.61 (0.45,0.83)	0.62 (0.46,0.85)	0.66 (0.49,0.90)	0.67 (0.49,0.91)
Musculoskeletal pain to Frequent SP (a)		0.49 (0.41, 0.58)		0.55 (0.45,0.67)		0.85 (0.68,1.06)		0.88 (0.70,1.10)
Frequent SP to Mental health (b)		3.15 (2.44,4.08)		2.98 (2.25,3.94)		2.39 (1.77,3.20)		2.15 (1.57,2.88)
Indirect effect		0.44 (0.32,0.56)		0.52 (0.38,0.67)		0.87 (0.69,1.04)		0.91 (0.74,1.07)
Model fit*	-867 (5)	-2378 (5)	-831 (7)	-2163 (15)	-786 (9)	-2084 (19)	-749 (10)	-2042 (21)
Baseline Mental health on 4YR Mental health							3.48 (2.60,4.67)	3.27 (2.43,4.38)

Results are given as Odds Ratios and 95% Confidence intervals

**Model fit is given as loglikelihood statistic (number of free parameters) smaller value suggests better fit*
Model 1 = Unadjusted model
Model 2 = Model 1 + adjustment for sociodemographic factors
Model 3 = Model 2 + adjustment for health factors (limiting chronic illness and poor self-rated health)
Model 4 = Model 3 + adjustment for baseline mental health
Shaded squares show ORs with 95% confidence intervals which are not significant at 5% level

EXAMINING SOCIAL PARTICIPATION EFFECT MEDIATION MECHANISMS; PHYSICAL ACTIVITY, SOCIAL SUPPORT AND A SENSE OF PURPOSE

In the mediation subsample, frequent socialisers had significantly higher prevalence of high physical activity, good social support and a sense of purpose than infrequent socialisers (p<.001 for each). The difference was greatest for a sense of purpose (85.6% cf. 59.0%) and high physical activity (85.6% cf. 62.0%). Both groups had high levels of social support (91.3% cf. 81.0%). In the unadjusted analysis,, when physical activity, social support and a sense of purpose were added as additional mediators in the multiple mediator model, three of the four indirect pathways were significant; social participation (p<.001), a sense of purpose (p<.001) and physical activity (p=.022), but not social support (p=.112). The a, b and c' paths for each indirect path are provided in Figure 7:8. VIF values demonstrated acceptable colliniearity between all variables in the models (all values <5.0). The indirect effect through social participation (OR:0.66; 95%CI:0.51,0.81) and physical activity (OR:0.70 95%CI:0.51,0.94) respectively were strong and significant. For a sense of purpose the indirect effect was even stronger (OR:0.16; 95%CI:0.10,0.24).



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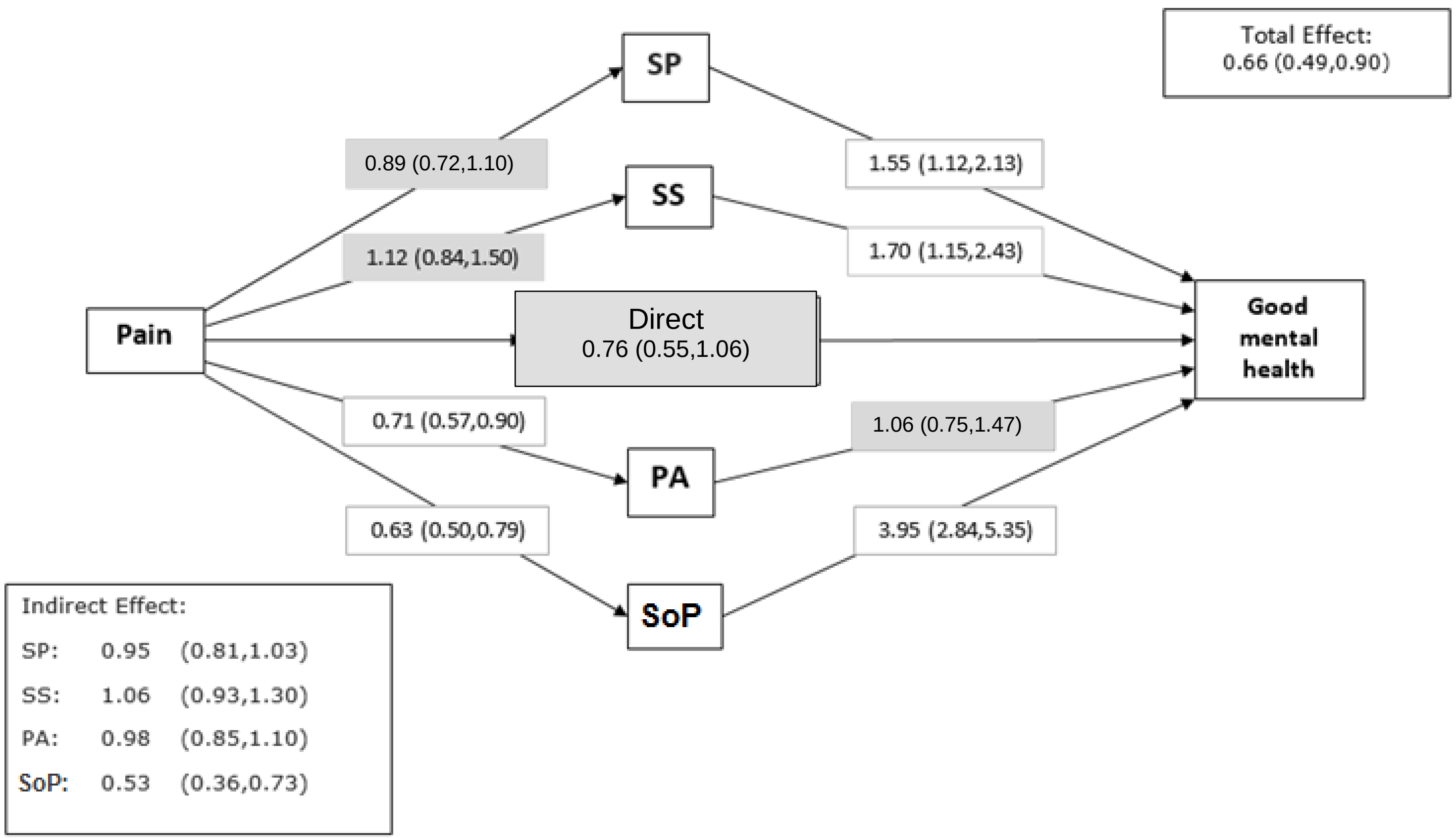

Figure 7:9 Path diagram of the fully adjusted model examining the mediating effect of multiple mediators in the effect of musculoskeletal pain on good mental health. Mediating variables are; social participation (SP), social support (SS), physical activity (PA) and a sense of purpose (SoP)

When all other covariates were adjusted for in the fully adjusted model, only one indirect pathway was significant; that of a sense of purpose (p<.001). For this pathway, older people with musculoskeletal pain who maintained a sense of purpose had almost twice the odds of good mental health compared to those with musculoskeletal pain who had a low sense of purpose [when coded so the natural indirect effect was interpreted as this (see page 245) an OR of 1.89 (95% CI: 1.36,2.79) was yielded]. VIF values demonstrated acceptable colliniearity between all variables in the models (all values <5.0). The odds ratios for each path component in the multiple mediator model are provided in Figure 7:9.

In the adjusted multiple mediator model, those with baseline musculoskeletal pain had lower odds of reporting a sense of purpose than those without musculoskeletal pain (OR:0.63, 95%CI:0.50,0.79), but those who did report a good sense of purpose had almost four times the odds of reporting good mental health compared to those with poor sense of purpose (OR:3.95, 95%CI:2.84,5.35). The association between musculoskeletal pain and mental health was attentuated to insignificance (OR:0.76;95%CI:0.55,1.06). Of the other putative mediators in the model, baseline musculoskeletal pain was predictive of subsequent levels of physical activity (p=.004) but not social support (p=.439). The association between baseline musculoskeletal pain and social participation also remained insignificant (p=.300). Both good social support and frequent social particicpation were associated with increased odds of subsequently reporting good mental health at 4-year follow-up (for social participation OR:1.55, and for social support OR:1.70) in older people, adjusting independently for baseline musculoskeletal pain.

SENSITIVITY ANALYSES

How likely is bias due to missing data?

During the sensitivity analysis when the models were re-run using cases with missing covariate data, the association of baseline musculoskeletal pain with good mental health at 4-years was similar, with an unadjusted OR of 0.30 (95%CI:0.23,0.38) for complete cases and an OR of 0.29 (95%CI:0.25,0.34) when cases with missing covariate data were included (Table 7:10). However in the adjusted model, there were differences in the odds ratios for the a and b paths, with the results of the missing-case analysis showing a shift towards the null (a path: OR 0.88 to 0.99 in missing-case analysis, and b path: OR 2.15 to 1.67). The mediating effects of the four putative mediators included in the multiple effect mediator model using cases with missing data were similar between the complete case and missing data analyses, with no difference in the inferences made. For example, the OR for frequent social participation in those with musculoskeletal pain was 0.89 (95%CI:0.72,1.10) for complete cases and 0.93 (95%CI:0.79,1.02) when cases with missing covariate data were included. The direct effect of musculoskeletal pain on good mental health differed in level of statistical significance between cases with missing data (OR:0.73;95%CI:0.59,0.79;p=.002), and the complete case analyses (OR:0.76;95%CI:0.55,1.06);p=.091). The results of the multiple effect mediator model using cases with missing data are reported in Appendix 6.

Table 7:10 Sensitivity analysis; Results of the complete-case (N=2654) and missing-data (N=7266) models for the unadjusted and fully adjusted total effects and decomposed models

Path	**Unadjusted model** *complete*		**Unadjusted model** *Missing*		**Adjusted model#** *complete*		**Adjusted model#** *missing*	
	Total Effect (c path)	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*
Musculoskeletal pain to Mental health	0.30 (0.23,0.38)	0.34 (0.27,0.45)	0.29 (0.25,0.34)	0.33 (0.30,0.36)	0.66 (0.49,0.90)	0.67 (0.49,0.91)	0.64 (0.61,0.73)	0.64 (0.61,0.73)
Musculoskeletal pain to Frequent SP (a)		0.49 (0.41,0.58)		0.54 (0.51,0.58)		0.88 (0.70,1.10)		0.99 (0.98,1.00)
Frequent SP to Mental health (b)		3.15 (2.44,4.08)		2.65 (2.54,2.83)		2.15 (1.57,2.88)		1.67 (1.38,1.73)
Indirect effect		0.44 (0.32,0.56)		0.55 (0.53,0.61)		0.91 (0.74,1.07)		1.00 (0.99,1.00)

Results are given as Odds Ratios and 95% Confidence intervals

#Represents odds of good mental health in a case scoring '0' on each variable in the model (e.g. in model I a male, aged 50-59, without economic adversity and engaged in a low amount of social participation activity)
#Adjusted model adjusted for sociodemographic and health factors and baseline mental health
Shaded squares show ORs with 95% confidence intervals which are not significant at 5% level

To what extent is the relationship between social participation and mental health recipriocal?

A sensitivity analysis was performed to examine the reciprocal relationship between social participation and mental health (Figure 7:10). Baseline social participation was a strong, significant predictor of mental health at two-years (OR:2.1: 95%CI:1.79,2.05) independent of the effect of baseline mental health (OR:5.7: 95%CI:5.06,6.63), and baseline social participation was a stronger predictor of social participation at two-years (OR:12.8: 95%CI:10.8,15.2) than was baseline mental health (OR:1.67: 95%CI:1,42,2.05).

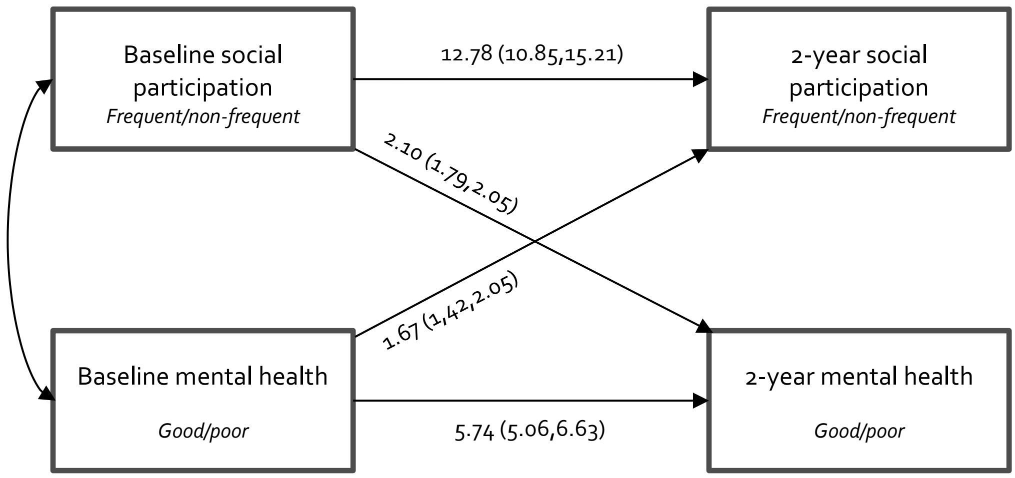

Figure 7:10 The reciprocal relationship between social participation and mental health at baseline and two-year follow-up. Results presented as ORs (95% CI)

Does the cut-off for social participation affect the study findings?

The basic mediation model was rerun using the two alternate cut-off values for dichotomising social participation. The association of baseline musculoskeletal pain with 'frequent' social participation at 2-year follow-up became weaker when the referent group included FreqLow socialisers (OR for a path went from 0.30 for infrequent versus all others, to 0.63 for FreqHigh versus others).

Next the association between social participation and good mental health was examined with social participation redefined using alternate cut-offs. The expectation was that mixing the groups so FrequentHigh and FrequentLow participants were either split or merged with moderate socialisers respectively, would attenuate any associations compared to those found in the main analysis (OR: 3.15; 95%CI:2.44,4.08). The association between social participation at 2-year follow-up and mental health at 4-year follow-up was weaker when social participation was defined using cut-offs above that used in the main analysis (i.e. infrequent/moderate and FrequentLow versus FrequentHigh) OR:1.80 (95%CI:<0.00,8.11) and there was no significant indirect effect (p= 0.906). Equally, when FreqLow socialisers were combined with infrequent and moderate socialisers in the referent group, the association between social participation and mental health at four-year follow-up also became weaker (OR:1.81:95%CI:1.37,2.45).

Does musculoskeletal pain severity influence the findings of any effect mediation?

When the distribution of musculoskeletal pain by severity was examined between social participation groups, a significant difference was found (p<.001) in the proportions with mild, moderate and severe pain. Of those with musculoskeletal pain in the Low socialiser group, 21.6% (n=185) reported mild pain, 54.5% (n=468) moderate pain and 23.9% (n=205) severe pain. In FreqLow socialisers these proportions were 39.8% (n=180), 49.6% (n=224) and 10.6% (n=48) respectively, and in the FreqHigh group 44.1% (n=154), 43.0% (n=150) and 12.9% (n=45). When the analyses were rerun, with those with mild pain excluded, the total effect of musculoskeletal pain on mental health was slightly stronger [OR:0.57 (95%CI:0.40,0.81) cf. OR:0.66 (95%CI:0.49,0.90)] but overall there was no difference in the inferences drawn. The decomposed effects were no different in significance and similar in effect size to those of the main analysis. As in the original analysis, the indirect effect was insignificant [OR:0.87 (95%CI:0.69,1.03);p=.181], and the direct effect of musculoskeletal pain on mental health significant, with odds of good mental health lower in those with musculoskeletal pain [OR:0.58 (95%CI:0.41,0.84);p=.003].

7.5.2 SOCIAL PARTICIPATION AS AN EFFECT MODIFIER

TESTING FOR STATISTICAL INTERACTION

In the unadjusted analysis (Table 7.11; Model 1a), baseline musculoskeletal pain was associated with good mental health at two-years follow-up (OR:0.35, 95%CI:0.31,0.40), as was FreqLow and FreqHigh social participation (FreqLow OR:2.40, 95%CI:2.05,2.84, and FreqHig OR:2.28,95%CI:1.91,2.72). There was a significant interaction between FreqLow and musculoskeletal pain (p=.014) and a positive but insignificant interaction between FreqHigh and musculoskeletal pain (p=.115).

In Model 2b, adjusted for age, gender and economic adversity, the significance of the interactions between musculoskeletal pain and FreqLow and FreqHigh socialisers respectively remained unchanged suggesting the interactions to be independent of differences in these sociodemographic factors between each frequent socialiser groups and the referent group. In both model 1 and 2, musculoskeletal pain was the strongest negative predictor of good mental health at two-year follow-up, with economic adversity, female gender and being aged 80 years and over also independently associated with reduced odds of reporting good mental health. Finally, when all sociodemographic factors (age, gender and economic adversity), self-rated health, chronic limiting illness and baseline mental health were added into the model, both interaction terms became insignificant. Musculoskeletal pain and frequent social participation remained significant predictors, with the odds of reporting good mental health at two-year follow-up in those with baseline musculoskeletal pain 0.65 (95%CI:0.55,0.77) of the odds of those without musculoskeletal pain. The odds of reporting good mental health at two-year follow-up was approximately 1.5 higher in the FreqHigh (OR:1.56;95%CI:1.27,1.92) and FreqLow (OR:1.50;95%CI:1.24,1.82) groups compared to infrequent socialisers.

When those with missing data were included in the analysis, the results were similar in both the unadjusted and fully adjusted models. However the FreqHigh group x musculoskeletal pain interaction became statistically significant in both Model 1b and Model 3b, suggesting frequent social participation with high social engagement is an effect modifier of the association between baseline musculoskeletal pain and good mental health at two-year follow-up, but frequent social participation with low social engagement is not (Table 7:12).

Table 7:11 Mental health effect modification models 1-3 without (a) and with (b) interaction terms (N=4747)

	Model					
	1a	**1b**	**2a**	**2b**	**3a**	**3b**
Musculoskeletal pain	0.35 (0.31,0.40)	0.30 (0.25,0.38)	0.38 (0.33,0.43)	0.31 (0.26,0.38)	0.65 (0.55,0.77)	0.61 (0.48,0.76)
Social participation: FreqLow	2.40 (2.05,2.84)	1.99 (1.60,2.48)	2.01 (1.68,2.40)	1.66 (1,32,2.09)	1.50 (1.24,1.82)	1.42 (1.12,1.80)
Social participation: FreqHigh	2.28 (1.91,2.72)	1.98 (1.56,2.54)	2.05 (1.70,2.49)	1.74 (1.36,2.26)	1.56 (1.27,1.92)	1.46 (1.12,1.91)
Interaction: FreqLow x Msk Pain		1.52 (1.09,2.12)		1.53 (1.09,2.15)		1.12 (0.83,1.62)
Interaction: FreqHigh x Msk Pain		1.34 (0.94,1.94)		1.41 (0.98,2.07)		1.17 (0.78,1.75)
Gender (female)			0.57 (0.49,0.66)	0.56 (0.49,0.65)	0.62 (0.52,0.72)	0.61 (0.52,0.72)
Age (years) 50-59			1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
60-69			1.16 (0.97,1.37)	1.16 (0.97,1.37)	1.12 (0.92,1.33)	1.12 (0.92,1.33)
70-79			0.88 (0.72,1.06)	0.87 (0.72,1.06)	0.86 (0.45,1.05)	0.86 (0.70,1.05)
80+			0.71 (0.54,0.94)	0.71 (0.54,0.93)	0.76 (0.57,1.03)	0.76 (0.57,1.03)
Economic adversity			0.56 (0.48,0.67)	0.56 (0.48,0.67)	0.67 (0.56,0.81)	0.67 (0.56,0.81)
Poor self-rated health					0.61 (0.56,0.81)	0.62 (0.51,0.76)
Chronic limiting illness					0.62 (0.52,0.75)	0.62 (0.52,0.76)
Baseline mental health					4.06 (3.46,4.74)	4.05 (3.45,4.74)
Intercept#	2.90 (2.59,3.25)	3.16 (2.77,3.65)	4.88 (5.91,4.06)	5.39 (4.41,6.65)	2.24 (1.78,2.85)	2.32 (1.82,2.98)
Model fit*	4957	4960	4854	4856	4404	4414

Results are given as Odds Ratios and 95% Confidence intervals
Insignificant associations are shaded grey

*#Represents odds of good physical health in a case scoring '0' on each variable in the model (e.g. in model III a male, aged 50-59, without economic adversity and engaged in a low amount of social participation activity) | *Model fit is given as adjusted BIC; lowest aBIC is preferred | Model 1 = Unadjusted Model 2 = Model 1 + adjustment for sociodemographic factors (age, gender and economic adversity) | Model 3= Model 2 + chronic limiting illness, self-rated health and baseline mental health.*

Table 7:12 Effect modification models 1 (unadjusted) and 3 (fully adjusted) with interaction terms for complete case and missing-data analyses.

	Model I *complete*	**Model I** *missing*	**Model 3** *complete*	**Model 3** *missing*
Musculoskeletal pain	0.30 (0.25,0.38)	0.52 (0.48,0.57)	0.61 (0.48,0.76)	0.58 (0.50,0.79)
Social participation: FreqLow	1.99 (1.60,2.48)	1.48 (1.39,1.64)	1.42 (1.12,1.80)	1.39 (1.13,1.79)
Social participation: FreqHigh	1.98 (1.56,2.54)	1.51 (1.36,1.67)	1.46 (1.12,1.91)	1.43 (1.32,1.79)
Interaction: FreqLow x Msk Pain	1.52 (1.09,2.12)	1.26 (1.16,1.42)	1.12 (0.83,1.62)	1.21 (0.86,1.56)
Interaction: FreqHigh x Msk Pain	1.34 (0.94,1.94)	1.23 (1.07,1.30)	1.17 (0.78,1.75)	1.24 (1.15,1.62)
Gender (female)			0.61 (0.52,0.72)	0.62 (0.54,0.67)
Age (years) 50-59			1.0 (ref)	1.0 (ref)
60-69			1.12 (0.92,1.33)	1.13 (0.92,1.28)
70-79			0.86 (0.70,1.05)	0.83 (0.75,0.97)
80+			0.76 (0.57,1.03)	0.74 (0.64,0.86)
Economic adversity			0.67 (0.56,0.81)	0.69 (0.60,0.77)
Poor self-rated health			0.62 (0.51,0.76)	0.64 (0.57,0.70)
Chronic limiting illness			0.62 (0.52,0.76)	0.62 (0.54,0.67)
Baseline mental health			4.05 (3.45,4.74)	4.03 (3.83,4.37)

Results are given as Odds Ratios and 95% Confidence intervals
Insignificant associations are shaded grey

#Represents odds of good mental health in a case scoring 'o' on each variable in the model (e.g. in model III a male, aged 50-59, without economic adversity and engaged in a low amount of social participation activity)
**Model fit is given as adjusted BIC; lowest aBIC is preferred*
Model I = Unadjusted including only pain, SP and interaction terms
Model II = Model I + adjustment for sociodemographic factors (age, gender and economic adversity)

EXAMINING DIFFERENCES BETWEEN SOCIAL PARTICIPATION SUBGROUPS

The findings from the initial interaction modelling phase indicated that social participation was a significant effect modifier of the association between baseline musculoskeletal pain and mental health at two-year follow-up. A fully adjusted multigroup model was run to adjust for putative confounders, and found the reduced odds of good mental health associated with reporting musculoskeletal pain was similar across all social participation groups;

- Low socialisers: OR:0.65 95%CI:0.50,0.84
- FreqLow: OR:0.66 95%CI:0.49,0.91
- FreqHigh OR:0.62 95%CI:0.43,0.93

Within each socialiser group, the odds of reporting good mental health at follow-up for those with musculoskeletal pain were approximately 0.6 compared to those without musculoskeletal pain. However, the intercept values for the frequent socialiser groups were larger than that of the Low socialiser group, suggesting the odds of good mental health in the respective referent groups were better in the frequent groups (approximately 3:1), compared to low socialisers (approximately 2:1).

Being in either the FreqLow or FreqHigh groups was associated with health factors having a less significant association with mental health compared to those in the Low group (Table 7:13). For FreqLow socialisers reporting chronic limiting illness was associated with lower odds of good mental health at two-year follow-up but there was no significant association for poor self-rated health. Meanwhile, for FreqHigh socialisers, poor self-rated health was associated with lower odds of good mental health, but reporting chronic limiting illness was not a significant predictor. Baseline mental health status remained the strongest single predictor of good mental health at two-year follow-up for all social participation subgroups (odds ratios ranged from 3.27-4.45).

Table 7:13 Fully adjusted model examining effect modification using multigroup analysis (N=4747)

	Multigroup model		
	Low	**FreqLow**	**FreqHigh**
Musculoskeletal pain	0.65 (0.50,0.84)	0.66 (0.49,0.91)	0.62 (0.43,0.93)
Gender (female)	0.54 (0.43, 0.68)	0.60 (0.45, 0.80)	0.82 (0.57, 1.15)
Age (years) 60-69	1.30 (0.98, 1.72)	1.06 (0.77, 1.45)	0.92 (0.61, 1.35)
70-79	0.92 (0.68, 1.23)	0.83 (0.55, 1.30)	0.83 (0.52, 1.30)
80+	0.93 (0.64, 1.35)	0.79 (0.37, 2.13)	0.45 (0.22, 0.93)
Economic adversity	0.72 (0.57, 0.90)	0.71 (0.46, 1.12)	0.48 (0.31, 0.80)
Limiting Illness	0.58 (0.44, 0.76)	0.53 (0.38, 0.77)	0.89 (0.58, 1.39)
Poor self-rated health	0.56 (0.43, 0.74)	0.83 (0.55, 1.31)	0.55 (0.34, 0.94)
Baseline mental health	4.45 (3.55, 5.57)	3.27 (2.37, 4.38)	4.16 (2.85, 5.89)
Intercept#	2.18 (1.58, 3.03)	3.90 (2.71, 5.78)	3.03 (1.85, 5.02)

Results are given as Odds Ratios and 95% Confidence intervals
Insignificant associations are shaded grey

#Represents odds of good mental health in a case scoring 'o' on each variable in the model (e.g. in model I a male, aged 50-59, without economic adversity and engaged in a low amount of social participation activity)
**Model fit is given as adjusted BIC; lowest aBIC is preferred*
Model I = adjustment for sociodemographic factors (age, gender and economic adversity) and health factors (limiting chronic illness and poor self-rated health)
Model II = Model I + adjustment for baseline mental health

Table 7:14 Complete case and missing data models for the fully adjusted effect modification multigroup analysis model

	Complete case model			Missing data model		
	Low	**FreqLow**	**FreqHigh**	**Low**	**FreqLow**	**FreqHigh**
Musculoskeletal pain	0.65 (0.50,0.84)	0.66 (0.49,0.91)	0.62 (0.43,0.93)	0.61 (0.49,0.78)	0.68 (0.51,0.93)	0.67 (0.46,0.99)
Gender (female)	0.54 (0.43, 0.68)	0.60 (0.45, 0.80)	0.82 (0.57, 1.15)	0.58 (0.47,0.72)	0.58 (0.43,0.76)	0.78 (0.55,1.10)
Age (years) 60-69	1.30 (0.98, 1.72)	1.06 (0.77, 1.45)	0.92 (0.61, 1.35)	1.26 (0.96,1.64)	1.08 (0.79,1.48)	0.96 (0.65,1.42)
70-79	0.92 (0.68, 1.23)	0.83 (0.55, 1.30)	0.83 (0.52, 1.30)	0.90 (0.67,1.18)	0.79 (0.53,1.21)	0.80 (0.51,1.27)
80+	0.93 (0.64, 1.35)	0.79 (0.37, 2.13)	0.45 (0.22, 0.93)	0.89 (0.64,1.28)	0.69 (0.34,1.60)	0.46 (0.24,0.94)
Economic adversity	0.72 (0.57, 0.90)	0.71 (0.46, 1.12)	0.48 (0.31, 0.80)	0.73 (0.59,0.90)	0.76 (0.50,1.19)	0.51 (0.31,0.84)
Limiting Illness	0.58 (0.44, 0.76)	0.53 (0.38, 0.77)	0.89 (0.58, 1.39)	0.62 (0.48,0.80)	0.54 (0.38,0.78)	0.77 (0.52,1.19)
Poor self-rated health	0.56 (0.43, 0.74)	0.83 (0.55, 1.31)	0.55 (0.34, 0.94)	0.58 (0.45,0.75)	0.84 (0.56,1.30)	0.65 (0.40,1.08)
Baseline mental health	4.45 (3.55, 5.57)	3.27 (2.37, 4.38)	4.16 (2.85, 5.89)	4.39 (3.53,5.39)	3.26 (2.38,4.34)	4.18 (2.89,5.88)
Intercept#	2.18 (1.58, 3.03)	3.90 (2.71, 5.78)	3.03 (1.85, 5.02)	2.11 (1.57,2.87)	3.92 (2.70,5.70)	3.03 (1.87,5.02)

Results are given as Odds Ratios and 95% Confidence intervals
Significant associations are in bold

#Represents odds of good mental health in a case scoring 'o' on each variable in the model
Model = adjustment for sociodemographic factors (age, gender and economic adversity) and health factors (limiting chronic illness and poor self-rated health) and baseline mental health

When cases with missing covariate data were included in the multigroup analysis using FIML estimation, there was little difference from the findings of the complete case analysis for many parameters (Table 7:14). However, for the FreqHigh group, the odds of poor self-rated health became statistically insignificant in the missing data analysis, crossing 1.0. However, there was little change in the OR estimates which stayed ±0.05 of 0.60. Both of the missing data analyses resulted in a poorer model fit statistic, and the findings were comparable for social participation, therefore the estimates from the complete case analyses were used to examine the role of social participation.

7.5.3 SOCIAL PARTICIPATION AS A CONFOUNDER

The findings from the confounding analyses suggest social participation is only a weak confounder of the association between baseline musculoskeletal pain and good mental health two years later, and this effect is lost when variation in age, gender, economic adversity, limiting chronic illness and poor self-rated health are accounted for. There was a small (<8.6%) proportion of confounding attributable to social participation in the otherwise unadjusted model, and this confounding persisted when the model was adjusted for age, gender and economic adversity. However, once adjusted for health factors (limiting chronic illness and self-rated health) this difference attenuated to 0%. Thus it appears that any confounding was due to differences in the prevalence of the two health factors between social participation groups (Table 7:15). Reanalysis using FIML to handle missing covariate data showed little differences between the proportion of change in the odds ratio of musculoskeletal pain with and without inclusion of social participation (Table 7:16), and the conclusion of no confounding was maintained.

Table 7:15 Incrementally adjusted models testing the role of social participation as a confounder of the association of baseline musculoskeletal pain and mental health at two-year follow-up (N=4747)

	Model I	**Model II**	**Model III**	**Model IV**
Musculoskeletal pain on mental health Model fit*	0.32 (0.28,0.36) 5095	0.35 (0.31,0.41) 4928	0.57 (0.48,0.67) 4737	0.65 (0.54,0.76) 4419
Musculoskeletal pain on mental health with inclusion of social participation Model fit	0.35 (0.31,0.40) 4957	0.38 (0.33,0.43) 4854	0.57 (0.49,0.68) 4702	0.65 (0.55,0.77) 4404
Magnitude of confounding *(difference/adjusted OR) %*	8.6%	7.9%	0.0%	0.0%

Results are given as Odds Ratios and 95% Confidence intervals

**Model fit is given as adjusted BIC; lowest aBIC is preferred*
Model I = Unadjusted
Model II = Model I + adjustment for sociodemographic factors (age, gender and economic adversity)
Model III= Model II + adjustment for health factors (limiting long-term illness and self-rated health
Model IV = Model III + adjustment for baseline mental health

Table 7:16 Unadjusted and fully adjusted models, using complete cases only and then FIML of missing covariate data, to test the role of social participation as a confounder of the association of baseline musculoskeletal pain and mental health at two-year follow-up

	Model I *complete*	**Model I** *missing*	**Model II** *complete*	**Model II** *missing*
Musculoskeletal pain on mental health	0.32 (0.28,0.36)	0.32 (0.29,0.36)	0.65 (0.54,0.76)	0.64 (0.55,0.74)
Musculoskeletal pain on mental health with inclusion of social participation	0.35 (0.31,0.40)	0.35 (0.31,0.39)	0.65 (0.55,0.77)	0.64 (0.55,0.76)
Magnitude of confounding *(difference/adjusted OR) %*	8.6%	8.6%	0.0%	0.0%

Results are given as Odds Ratios and 95% Confidence intervals

Model I = Unadjusted
Model II = Unadjusted + adjustment for sociodemographic and health factors and baseline mental health

7.6 DISCUSSION

7.6.1 SUMMARY OF FINDINGS

This study has used a series of empirical analyses to test the role of social participation in maintaining mental health in older people with musculoskeletal pain. The findings are summarised in Table 7:17 below. The unadjusted results indicate that social participation is an effect modifier (i.e. identifying groups with different strengths of association), a confounder (i.e. distorting the true association) and an effect mediator (i.e. explaining why an association is observed) of the association between baseline musculoskeletal pain and subsequent good mental health in older people. However, once differences in sociodemographic, chronic limiting illness, self-rated health and baseline mental health status were adjusted for, no mediating or confounding effects by social participation of the association between musculoskeletal pain and mental health remained. Social participation did remain an effect modifier, with a significant interaction between musculoskeletal pain and subsequent mental health suggesting a difference in association in frequent socialisers compared to that of infrequent socialisers. When probed further using multigroup analysis, the odds ratio for the association of musculoskeletal pain with mental health was approximately equal for all social participation groups (OR approximately 0.6), although the intercept value (representing the risk in a typical case possessing all of the referent characteristics) was higher in infrequent socialisers. This suggests that the ratio in odds of good mental health, attributable to musculoskeletal pain, remains consistently 0.6 of that of those with no musculoskeletal pain regardless of their social participation group, but that the odds of good mental health are lowest in the infrequent socialiser referent group.

The multiple mediator analyses test whether any effect mediation persisted through social participation when social support, a sense of purpose and physical activity were included in the model. Results showed a significant indirect effect of musculoskeletal pain on mental health through social participation persisted in the otherwise unadjusted model. In the fully adjusted model a significant indirect effect existed only through a sense of purpose. A sense of purpose, which the underlying theoretical model suggests can be attained through social participation activities, consequently appears to explain why some older people with musculoskeletal pain maintain their mental health even after putative confounders (i.e. sociodemographic factors, self-rated health and chronic limiting illness) are accounted for. The indirect effects through social participation and physical activity did not persist, and no indirect effect through social support was found in either the unadjusted or adjusted analyses. Furthermore, the direct effect of musculoskeletal pain upon mental health which persisted in the fully adjusted model, suggests a sense of purpose alone does not fully explain the negative effect of musculoskeletal pain upon mental health in older people.

Table 7:17 Study findings: a summary of the role of social participation in determining mental health in older people with musculoskeletal pain

Analyses	Unadjusted analysis	Adjusted[1] analysis
Effect modifier: Social participation	**Yes**	**Yes**[2]
Confounder: Social participation	**Yes**	No
Effect mediator: Social participation	**Yes**	No
Multiple effect mediators:		
Social participation	**Yes**	No
Physical activity	**Yes**	No
Social support	No	No
A sense of purpose	**Yes**	**Yes**

[1] Adjusted for age, gender, economic adversity, poor self-rated health, limiting long-term illness and baseline mental health
[2] In the FIML analyses including cases with missing covariate data

Conceptually, a variable which fulfils the role of effect moderator cannot also be a confounder as, if an association is real but the magnitude of the association differs depending on that third variable, then the third variable is an effect modifier, whereas as a confounder obscures the magnitude and/or direction of a true association or creates a spurious one (Szklo & Nieto, 2014). This conceptual differentiation was supported by the empirical findings of the analyses, which showed that social participation was not a confounder once additional putative confounders were adjusted for, but did remain an effect modifier.

The study also provided an insight into the longitudinal pattern of mental health in older people, and the impact of musculoskeletal pain upon subsequent mental health. Most individuals had stable mental health between baseline and follow-up (whether measured two or four years later). For those who did report a change in mental health it was approximately twice as likely to be a deterioration from good to poor mental health, rather than an improvement from poor to good mental health. Of all the independent variables, baseline mental health was the strongest single predictor of mental health at two and four-year follow-ups. The negative association between musculoskeletal pain and subsequent odds of good mental health persisted even when differences in social participation, sociodemographic and health factors are accounted for.

7.6.2 COMPARISON WITH PREVIOUS LITERATURE

Of the five studies examining the role of social participation as either an effect mediator or effect modifier of the association of musculoskeletal pain on health conditions identified in the systematic review (Chapter Four), four focussed on mental health outcomes. None of the studies explored the role of social participation in the association between musculoskeletal pain and maintaining mental health. Three focussed on depressive symptoms (Lòpez-Lopez et al., 2014; Mavandadi et al., 2007, & Parmelee et al., 2007), of which all examined social participation as an effect mediator. Lopez-Lopez and colleagues (2014) additionally considered social participation as an effect modifier, and a fourth study (Blyth et al., 2008) included a supplementary analysis testing for effect modification by care-giving status although results were not fully reported. Overall, none of these studies provided conclusive evidence to support social participation frequency as an effect mediator or effect modifier of the association between musculoskeletal pain and good mental health.

In this study, the path analyses testing for effect mediation found reporting musculoskeletal pain was associated with reduced odds of frequent social participation at two-year follow-up. Although the measure of social participation used in this study did not capture social participation restriction, it is likely that many of those in the Low socialiser group experienced restricted social participation as other studies have identified musculoskeletal pain as a predictor of social participation restriction (Wilkie et al., 2016;Theis et al., 2013;Wilkie et al.,2007). However, in the fully adjusted multiple mediator model in this study, the association between musculoskeletal pain and social participation became insignificant, suggesting that, if all other variables included in the model can be controlled, then the odds of frequent social participation in those with musculoskeletal pain do not significantly differ from those of older people without musculoskeletal pain. This finding adds to existing evidence that social participation can be maintained despite musculoskeletal pain (e.g. Jordan et al., 2012;). For example, the study by Mavandadi and colleagues (2007) suggested that musculoskeletal pain does not predict the frequency of positive social interactions. It is possible that although activities may be restricted by musculoskeletal pain, fulfilling social experiences can still be experienced. The association between social participation and subsequent good mental health remained strong and positive in all statistical models tested, supporting the role of social participation as a predictor of good mental health in older people independently of pain status.

In the fully adjusted analyses, social participation was not an effect mediator of the association between musculoskeletal pain and mental health in this study. Similarly, in a cross-sectional analysis, Parmelee and colleagues (2007) found activity participation did not mediate the relationship between musculoskeletal pain and depressive symptoms, but activity *limitation* and physical disability both did (although activity participation was an independent predictor explaining variation in depressive symptoms). As Parmelee and colleagues used a cross-sectional design, it is only possible to determine correlation, rather than causation, from their findings but they suggest different associations with depressive symptoms exist for performed participation versus restriction. These findings suggest that mechanisms determining the pathway between musculoskeletal pain and poor mental health are not the same as those which explain how those with musculoskeletal pain maintain good mental health, emphasising the importance and novelty of this study which focusses specifically on maintaining good mental health in older people with musculoskeletal pain. In the multiple mediator model, the lack of significant pathway through physical activity in determining mental health in older people with musculoskeletal pain was unexpected given the body of evidence for the benefits of physical activity on mental health (Penninx, et al., 2002; Strawbridge, et al., 2002). For example, Strawbridge and colleagues (2002) found physical activity was associated with decreased odds of prevalent (OR-0.90, 95% CI = 0.79–1.01) and incident depression over 5 years (OR = 0.83, 95% CI = 0.73–0.96) in older adults aged 50-94 years (n=1947).

The finding that social participation is an effect modifier of the association between musculoskeletal pain and mental health in this study supports that of the two previous studies identified in the systematic review. As in this study, Lopez and colleagues (2014) found social participation to be a significant effect modifier, with a significant association between musculoskeletal pain and depressive symptoms only in those with activity restriction (measured as a composite measure which included social participation activities), and not those without restriction. This also resonates with the finding when testing for effect mediation, that the direct effect of musculoskeletal pain upon mental health can be explained by other factors (i.e. in the fully adjusted multiple mediator analysis, the direct effect became insignificant). Blyth and colleagues (2008) found social participation (defined specifically in terms of care-giving roles) to be a significant effect modifier of the association between musculoskeletal pain and psychological distress. However, as care-giving was the primary factor, the referent group was non-caregivers. Caregiver status cannot be assumed however to be a proxy for overall social participation as other, non-caregiving social activities may be restricted due to care-giving roles (Longacre, et al., 2016), and care-giving is often a source of stress rather than beneficial to wellbeing (Newell, et al., 2012; Schulz & Sherwood, 2008). Therefore, the findings of Blyth and colleagues are difficult to compare to those of this study. A cross-sectional study by Benka and colleagues (2016), of a population that was too young to meet the study inclusion criteria of the systematic review reported in Chapter Four, supports the findings in this study that social participation is an effect modifier of the association between musculoskeletal pain and good mental health. The study explored associations between restrictions in social participation (defined as none, low, moderate or high) and rates of anxiety and depression in early and established rheumatoid arthritis patients (N=255; mean age 52 years). Stratified analyses suggested social participation restriction to be an effect modifier of the association between rheumatoid arthritis and depression and anxiety respectively, with those with moderate and high levels of restriction being significantly more likely to report either mental health condition than those with no social participation restriction (Benka, et al., 2016). Their model also accounted for musculoskeletal pain, fatigue, functional disability and disease activity.

The mediating effect of functional performance (e.g. social participation or physical disability) on the association between musculoskeletal pain and mental health appears to become weaker with increasing age (Mausbach, et al., 2011). This may be due to the fact that there are differences in socially accepted norms regarding expectations of social activity in older age due to lifespan developmental changes (Moore, et al., 2014). But there also appears to be great variation in the impact of musculoskeletal pain upon social participation in older people with musculoskeletal pain (e.g. Jordan et al., 2012 and the findings in this study that the direct effect of musculoskeletal pain on mental health becomes insignificant once adjusted for putative confounders). This may be due to the broad range of biopsychosocial factors and environmental factors, which can support or hinder the ability and desire to socially participate. Such factors also influence how musculoskeletal pain is experienced. Additionally, social participation can be measured in a number of varied methods, which could influence the associations identified. Furthermore, in studies of older cohorts, such as this study, variables capturing function are often predictors in their own right, independent of musculoskeletal pain (Mausbach et al., 2011, Parmelee et al., 2007).

7.6.3 STRENGTHS AND LIMITATIONS

ELSA

The main advantage of using the ELSA dataset is that it provided pre-collected, longitudinal cohort data specifically designed for examining the dynamics between social factors, health and functioning, and economics. As well as having expertise in terms of data collection and study design, the project has sufficient resources[11] to collect a large amount of data from a high volume of participants. The sampling frame was selected to be nationally representative, and the large sample size reduced the probability of a finding that is due to chance (Szklo & Nieto, 2014). Validated and well-established measures were used to capture all covariates, musculoskeletal pain and mental health. Much of the data was self-reported, which has been shown to provide an accurate measure of health impairments and functional problems in older people (Thinggaard, et al., 2010).

Nevertheless, there were some limitations. The sample was predominantly Caucasian, and as cultural differences influence social roles and social activities older people engage with (Lindström, 2005), it is likely that the findings of this study may differ to those found in similar studies conducted on specifically non-Caucasian populations. Another limitation of secondary data analysis is that data beyond that of interest to the research question is often collected in the original study, which can result in high participant burden and have a detrimental impact on attrition and missing data (Robinson, et al., 2007). Furthermore, in ageing studies, attrition of the least healthy participants is common as they may not be

[11] ELSA is funded by the US National Institute on Ageing and by a consortium of UK government departments led by the Office for National Statistics - ONS - (Department of Health, Department of Work and Pensions, Department of Environment, Transport and the Regions, Department for Education and Skills, Department of Culture, Media and Sport and HM Treasury).

capable of dealing with the burden of participation due to ill health and disability reasons (Mein, et al., 2012). While asking certain key questions from proxy informants (usually relatives or carers) is a standard method, this method may be subject to considerable recall biases. A 'healthy survivor effect' may be observed, whereby people remaining in the study demonstrate healthier behaviours and are more capable than those who are lost (Ramage-Morin, et al., 2010). Missing data and attrition can therefore threaten a study's internal and external validity, and reduce the power of statistical analyses (Szklo & Nieto, 2014).

STUDY SAMPLE AND SUBSAMPLE

As mentioned in the previous section, there was risk of selection bias arising from attrition due to the burden of the ELSA data collection process and age group being studied. Of the 7266 participants included in the LCA analysis (reported in Chapter Six), 65% (n=4747) composed the moderation sample, and 36% the mediation subsample (n=2654). Comparison of the characteristics of those providing complete data and those lost to attrition demonstrate a healthy survivor effect in this study. As an example, the mediation subsample was overall healthier than the ELSA sample in terms of musculoskeletal pain prevalence, self-rated health, chronic limiting illness and mental health. Furthermore, the mediation subsample were less likely to report baseline musculoskeletal pain. Whilst longitudinal data was important to enable the role of effect mediator to be effectively tested, disproportionate attrition of participants with the poorest health, many of whom were infrequent socialisers, posed a threat to the external validity of the findings and reduced the power of the respective tests (Lindsted, et al., 1996). To address this potential bias sensitivity analyses were performed using all available cases and full information maximum likelihood estimation methods to accommodate missing data.

The proportion of potential respondents constituting the moderation sample and mediation subsample in this study were acceptable considering the longitudinal nature, burdensome data collection process and elderly age of participants. Once those baseline participants who dropped out or were missing necessary data were excluded, response in the moderation/confounding components of the study was 48.2%, and for the mediation sample 28.9%. This response rate is comparable with other community health cohorts (Fekete, et al., 2015). The proportion of frequent socialisers in the moderation sample is similar to that expected based on a Canadian older population survey of adults 45 years or older (Ramage-Morin, et al., 2010), which defined frequent social participation as participating in community-related social activities at least weekly (58.8% cf. 59.8%).

There was a difference in findings between the complete-case and missing-data effect modification model findings. The FreqHigh group were older on average than the FreqLow group. It is unlikely that age would alter the magnitude or direction (i.e. effect modification) of the relationship between social participation and good mental health, as social participation has been associated with better mental health even in the oldest old (Cherry et al., 2013). However, it is possible that the potential influence of social participation on good mental health becomes less potent with increasing age, and as such age may be a moderator of the effect modifying effect of social participation. Moderated moderation models, which can identify more complex moderation effects than simple moderation models, could be used to examine this further (Hayes, 2013).

SOCIAL PARTICIPATION

The strengths of the measure of social participation are provided in detail in Chapter Six, and include capturing a broad range of social activities and role fulfilment into a single categorical variable, enabling the health characteristics of people with similar social participation characteristics to be examined in relation to the thesis objectives. The measure of social participation focussed on capturing the extent and purpose of activities. The lack of a measure of an individual's satisfaction with their extent of social participation may be considered a potential effect modifier of the role of social participation in determining mental health in older people with musculoskeletal pain. A related concern is that some individuals may be satisfied with infrequent social participation, enjoying their own solitude, while others are not. However, information about an individual's satisfaction with their social participation activities was not available in the ELSA dataset for all the activities contributing to the LCA. Reduced or restricted social participation, which is associated with poor health outcomes (Wilkie, et al., 2007; Glass, et al., 2006), was also not measured directly. However, chronic limiting illness was included as a putative confounder in the model and is likely to capture any limitation affecting social participation activities arising from health conditions, which includes musculoskeletal pain, the focus of this thesis.

The amalgamation of the infrequent and moderate social participation groups for the analyses, and the merging of frequent high and frequent low socialisers for the examining effect mediation, increased the power of the respective analyses and interpretability of the mediation analysis, which would have been more challenging had social participation been coded as a nominal variable. However, the limitation of this approach was that information is lost when a variable is coded as a binary variable rather than using full available information (Jung, 2014). Despite this, comparison of the health and sociodemographic characteristics associated with each social participation group (reported in Chapter Six) suggested moderate socialisers were more similar to infrequent socialisers than frequent socialisers in terms of their scores. Additionally, a sensitivity analysis was conducted to test whether the choice of cut-off for the binary social participation variable influenced the study findings. The results supported the cut-off selected for this study, with moderate and infrequent socialisers in one category, and FreqHigh and FreqLow socialisers in the other category. When moderate and frequent low socialisers were combined with infrequent socialisers, the effect of social participation became insignificant and the strength of the effect of FreqHigh SP on mental health was attenuated by the addition of FreqLow socialisers to the referent group.

MENTAL HEALTH

Mental health was measured using the CES-D 8, which is designed to measure depressive symptoms, so it is possible that some older people categorised as having good mental health may not have had depressive symptoms but may have been experiencing symptoms of a different mental illness (e.g. schizophrenia). The prevalence of good mental health may thus be inflated, introducing a source of systematic bias in measures of association between mental health and other factors. However, depression is the dominant mental health condition in this age group (McWilliams & Goodwin, 2004), and depressive symptoms commonly co-occur with other symptoms of poor mental health in older people (Schoevers et al., 2003; Beekman et al., 2000). Consequently, the occurrence of such measurement error is likely to be low. Furthermore, the items of the CES-D 8 have face validity in terms of capturing good mental health, which refers to 'the degree to which one feels positive and enthusiastic about oneself and life' (Manderscheid et al., 2010). As this study was exploratory, seeking to identify trends of association rather than distinguish an effect size, the measure of mental health used does not greatly threaten the robustness of the inferences. The study was still able to identify an association between musculoskeletal pain and the mental health outcome, and then explore the effect of social participation upon it. The limitation of the study relating to how mental health is defined is that this relationship may differ if mental health is defined in terms of absence of other mental health symptoms.

While this study adjusts for baseline mental health, poor mental health may be a recurrent problem occurring at intervals across the life course, with earlier onset associated with greater chance of recurrence (Burcusa & Iacono, 2007). Depressive symptoms which manifest early on in life are more likely to be associated with genetic, personality and life experience factors, whilst depressive symptoms which first develop in later life are more likely to bear some relationship to physical health problems (Singh & Misra, 2009). It is possible therefore that role of social participation in the association between baseline musculoskeletal pain and mental health at follow-up depends upon the underlying mechanisms, and these mechanisms may differ depending on the aetiology of the depressive symptoms or between social participation groups. Those experiencing recurrent depressive symptoms across the life-course may have developed behaviours or ways of coping which help them manage and maintain their mental health (Billari, 2009), such as using social participation. Mental illness, comorbid to musculoskeletal pain, increases the predisposition of self-neglect and undermines the ability to cope with the pain (Turner & Kelly, 2000), and may reduce the likelihood of maintaining social participation.

Finally, it is important to consider the potential overlap between mental health and a sense of purpose (defined using a measure of eudaimonic wellbeing) in this study. Conceptually, mental health is a state of successful performance of mental function, resulting in productive activities, fulfilling relationships with other people, and an ability to adapt to change and to cope with adversity (DHHS, 1999). A sense of purpose is the actualisation of self-development, personal growth and purposeful engagement which give meaning to an individual's existence (Ryff et al., 2004). It may be suggested that having no sense of purpose may constitute a lack of mental health. However, a sense of purpose is fundamentally linked to perceptions of having the ability to act independently and to make one's own free choices (Waterman, 1993), while depression is defined as a condition presenting with 'depressed mood, loss of interest or pleasure, feelings of guilt or low self-worth, disturbed sleep or appetite, low energy and poor concentration' (WHO, 2012). A sense of purpose and (absence of) depressive symptoms are conceptually distinct (Gharaibeh et al., 2016), and the VIF calculated for a sense of purpose within the fully adjusted model was an acceptable 1.3 (indicating acceptable collinearity). Both those with and without depression can potentially express agency, and one does not have to be depressed to have no sense of purpose. Studies examining a sense of purpose/agency/eudaimonic wellbeing as a predictor of depression have found a sense of purpose routinely to promote subsequent mental health (Culph et al., 2015;Slaby et al., 2013;Wood & Joseph, 2010), supporting the theoretical model underpinning this study which proposed that a sense of purpose was causally associated with good mental health.

MUSCULOSKELETAL PAIN AND COVARIATE MEASUREMENT

The definition of musculoskeletal pain used in these analyses, was based on the response to one question; 'are you often troubled by pain?'. Specifically asking participants to report only 'troublesome pain', or that lasting one day or longer can reduce the chance that minor aches or very transient, non-recurrent pain are captured in health surveys (Croft, et al., 2010). It is also important to differentiate the interference that musculoskeletal pain causes from reports of any pain, and there is evidence from large community samples that musculoskeletal pain interference may increase consistently with age even as incidence of musculoskeletal pain does not change (Thielke, et al., 2012). It is also possible that the number of pain sites and pain intensity, which have been shown to influence disability (Lacey et al., 2014;Jordan et al., 2012), may influence the association of musculoskeletal pain with subsequent mental health. As the number of anatomical sites affected increases so too does the impact of musculoskeletal pain (Buchman, et al., 2010; Wilkie, et al., 2007). However, pain site data was not available for all body areas, and sensitivity analyses showed no difference in inferences drawn when the mediation analyses were rerun comparing those without pain against only those with moderate or severe pain. Further adjustment for pain medication was not included in this study (ELSA only collected data on use of pain medication in those who reported hip or knee pain, using a follow-up question of 'Are you taking any medication for your pain?').

The measure of limiting chronic illness may capture limitation arising from musculoskeletal pain and attenuate the estimated effect of musculoskeletal pain on good mental health. However, to neglect to account for disability may have spuriously deflated the estimated effect of musculoskeletal pain, as limitation in daily life arising from other conditions would be likely to also be negatively associated with subsequent mental health (Kuh et al., 2014; Lopez-Lopez et al., 2014;Cucciare et al., 2010). Further research should seek to delineate disability arising from musculoskeletal pain and that arising from other chronic conditions, although this is likely to be methodologically challenging due to the common comorbidity of musculoskeletal pain and other age-related chronic conditions (Prados-Torres et al., 2014; Marengoni et al., 2011).

ANALYSIS

The use of secondary data analysis meant only data available in ELSA could be used in analyses, but provided a key strength of this study in that data collected at three different time points over a six-year period were ready and available for analysis. A common criticism raised against studies testing for effect mediation is regarding the use of cross-sectional data, which does not account for temporality of factors, and can lead to biased and misleading findings (Maxwell & Cole, 2007). The use of longitudinal data enabled the research objectives to be appropriately conducted, following best practice when testing for effect modification and effect mediation (Hayes, 2013; Gelfand, et al., 2009). The correct temporal relationship between variables when examining effect mediation is highly important (MacKinnon, et al., 2014), especially in cohort studies where baseline characteristics are not randomised at baseline (Szklo & Nieto, 2014). It is not sufficient to show that there is theoretical justification for a specified relationship between variables, but rather there must be, as a minimum, time elapsed between a putative cause and its associated effect to allow for an effect to occur (Preacher, 2015).

Using predictor variables measured at an earlier time point to mental health measurement reduced the threat of reverse causality on the validity of findings (Hayes, 2013). Additionally, reciprocal relationships should also be considered when testing for effect mediation (Maric, et al., 2012). However, while poor health may lead to subsequent reduced social participation (Theis & Furner, 2011; Wilkie, et al., 2007), it is theoretically unlikely for good health to *cause* social participation to be maintained, but rather it may be an enabler. This assumption was checked empirically as part of the sensitivity analyses (Section 8.5.1.3). A reciprocal effects model of mental health (good vs poor) and social participation (frequent vs non-frequent) was run to examine the longitudinal interrelationship between the two factors. The findings indicate that whilst a simultaneous reciprocal association does occur, social participation strongly predicts future mental health. Baseline mental health was also included in the final stage of adjustments to take account of health status at the start of the study. Potential confounders were identified for the analytical model and also included in the analysis. However there may have been other factors that could cause the association between musculoskeletal pain and mental/physical health that were not included.

Additional sensitivity analyses were performed to test the effects of attrition, the cut-offs used to group people based upon their social participation and whether pain severity would alter any mediating effect of social participation. The findings supported the cut-offs selected based upon theoretical distinctions (i.e. merging the two frequent socialiser groups when testing for effect mediation, with infrequent and moderate socialisers combined as a referent group) and found no difference in the inferences drawn when pain severity was used to predict good mental health. The OR estimates of the multigroup effect modification complete case analysis, compared to the FIML analysis, were similar across all groups. However, in the FIML analysis the overlap between the 95%CI's reduced and they shifted apart slightly, suggesting the true association of musculoskeletal pain to be greater than that yielded in the complete case analysis. This is likely due to the disproportionate attrition of the most unwell or disabled participants between baseline and follow-up resulting in a slightly healthier than average sample of older participants. One limitation of this study was that, although ORs provide a useful way of examining for differences in the odds of good mental health between two groups (e.g. pain versus no pain or infrequent socialisers versus frequent socialisers), they are not readily interpretable in terms of the absolute risk.

7.7 CHAPTER SUMMARY

This study contributes to the limited body of evidence examining the role of social participation in determining which older people with musculoskeletal pain maintain mental health. The findings suggest social participation to be an effect mediator and effect modifier of the association between musculoskeletal pain and mental health, and appears to be the first to focus specifically on good mental health as the outcome. Social participation appears to weakly explain how some older people with musculoskeletal pain maintain their mental health, although this effect seems better explained in terms of social participation constituting a vehicle by which older people can achieve a sense of purpose. Whilst no other studies have been identified which examine the role of social participation in maintaining good health in older people with musculoskeletal pain, those which have done so have also found evidence to suggest social participation to be a weak effect mediator. This study contributes to the evidence suggesting social participation is an effect modifier of the association between musculoskeletal pain and good mental health.

CHAPTER EIGHT: THE ROLE OF SOCIAL PARTICIPATION IN DETERMINING PHYSICAL HEALTH

8.1 CHAPTER OVERVIEW

This chapter describes the quantitative study addressing Objective 5 of the thesis; to investigate the role of social participation in determining the association between musculoskeletal pain and subsequent physical health in older people.

8.1.1 INTRODUCTION

Poor physical health is a common problem in the older general population (Kuh et al., 2014), and older people with musculoskeletal pain have increased risk of deteriorating self-rated health and comorbidity (Dominick et al., 2012;Dawson et al., 2005). Some older people maintain their health over time despite reporting musculoskeletal pain (Jordan et al., 2012), although it is not yet clear what factors determine which older people do so. Social participation has been linked to better physical health (Golden et al., 2009), and suggested as a protective factor in older populations independently of the benefits associated with maintaining physical activity (Umberson & Montez, 2010;Glass et al., 1999). However, the systematic literature search performed as part of this thesis identified a lack of empirical evidence of the role of social participation in determining the maintenance of physical health in older people with musculoskeletal pain. This chapter reports the quantitative study performed to empirically test whether social participation fulfils the role of effect mediator, effect modifier and confounder of the association between musculoskeletal pain and physical health. A detailed, evidence-based rationale supporting the hypotheses tested in this study is provided in Section 3.2 of Chapter Three.

The theoretical model used to develop the statistical models is described in more detail in Figure 2:4 of Chapter Two.

8.1.2 CHAPTER AIM AND OBJECTIVES

To address Objective 5 of the thesis three distinctive hypotheses were tested, each relating to one of the possible third variable roles social participation may fulfil (depicted in Figure 8:1):

a. Social participation is an effect mediator of the association between musculoskeletal pain and physical health in older people (role 1)

b. Social participation is an effect modifier of the association between musculoskeletal pain and physical health in older people (role 2)

c. Social participation is a confounding variable, distorting the true association between musculoskeletal pain and physical health in older people (role 3)

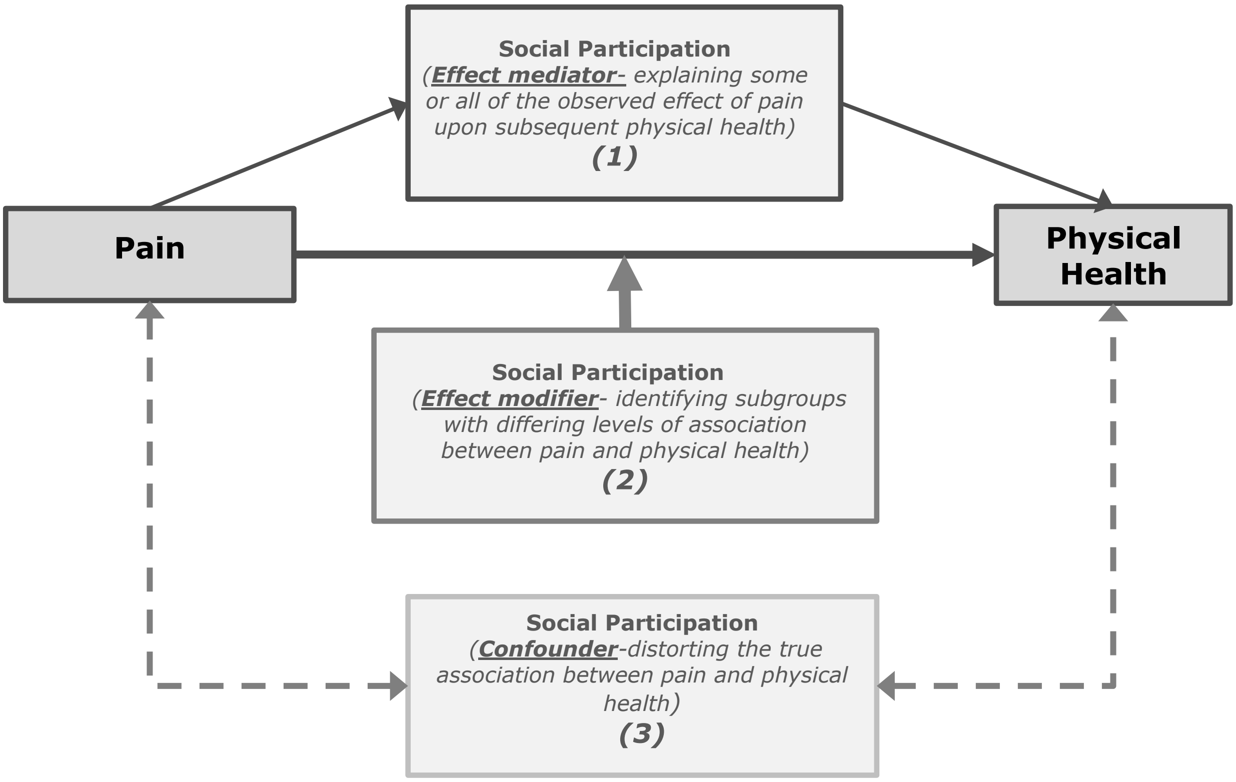

Figure 8:1 The proposed roles of social participation in the association of musculoskeletal pain on physical health in older people

8.2 METHODS

8.2.1 STUDY DESIGN

This study used data collected from older people recruited as part of the English Longitudinal Study of Ageing (ELSA), described in more detail in Chapter Five. As in the study reported in Chapter Seven, effect modification and confounding were tested for using data collected from two time points; baseline (data collected: June 2004-July 2005) and two-year follow-up (data collected May 2006-August 2007) while tests for effect mediation used an additional four-year follow-up (data collected: May 2008-July 2009).

8.2.2 VARIABLE CODING

Variables were coded as previously described in this thesis, and are summarised in Table 8:1.

Table 8:1 Summary of variables used in the physical health analyses

Variable name	Data source	Categories
Musculoskeletal pain	Self-reported often troubled by pain	Yes (often troubles by pain)/ No (not often troubled by pain)
Social participation	As described in Chapter Seven, Section 7.2.1. Different variables were used for testing effect modification/ confounding[12], to effect mediation[13]	
Physical health	Self-rated health	Good (excellent/very good/ good)/ Poor (fair/poor)
Gender	Self-reported and UK census data	Male/ Female
Age (years)	Self-reported and UK census data	50-59 (ref), 60-69, 70-79, 80+
Economic adversity	Baseline total net non-pension wealth (self-reported)	Yes (lowest quintile)/ No (other quintiles)
Poor mental health	8-item Center for Epidemiologic Studies on Depression (CES-D) questionnaire	Good (score ≤3)/ Poor (score ≥4)
Chronic limiting illness	Two questions identifying troublesome long-standing illness, disability or infirmity that limited daily activities	Yes (limiting long-standing illness)/ No (non-limiting or no chronic illness)
Physical activity	Derived variable based upon frequency and intensity of physical activity and occupational status.	High (moderate or high physical activity levels)/ Low (low and sedentary physical activity levels)
Social support	Operationalised as an index score of 12 items capturing social embeddedness	Good (Highest two tertiles)/ Low (Lowest tertile)
A sense of purpose	15 items from the CASP-19 quality of life questionnaire	Good (Highest two tertiles)/ Poor (Lowest tertile)

[12] The infrequent and moderate groups were combined to create a referent '**Low**' group who engaged in low or moderate social activities, to which the two frequent socialiser groups (**FreqLow** and **FreqHigh**) could be compared.

[13] A binary measure was created coding those maintaining or moving into the FreqHigh or FreqLow social participation groups between baseline and two-year follow-up as '**Frequent socialisers**' and those who remained or moved into the Low referent group as '**Non-frequent socialisers**'.

8.3 STATISTICAL ANALYSIS

8.3.1 POPULATION CHARACTERISTICS

Statistical analyses followed those used in the mental health analyses, described in Chapter Seven. A flow diagram of participants used in analyses is provided in Figure 8:2 later in the chapter. Participant characteristics were examined overall for the sampling frame, and then for those who provided complete data for the respective analysis. To examine for response bias, cross-tabulation was used to explore any differences in age and gender between the UK older population, ELSA respondents and the analytical samples (i.e. the moderation/confounder sample and the mediation subsample). Differences between the baseline characteristics of each social participation group were examined using chi-square statistics and Bonferroni adjusted p-values. Maximum likelihood estimation was used in all logistic regression models and bootstrapped 95% confidence intervals were calculated for all coefficient estimates (with 10000 draws). All regression models were estimated using MPlus version 7.2 (Muthén & Muthén, 2015). Descriptive analyses were performed in IBM SPSS 21.

8.3.2 TESTING POSSIBLE THIRD VARIABLE ROLES

The statistical analyses used were the same as those in the mental health analyses. For all analyses results were calculated as beta coefficients (β), and then converted to odds ratios (ORs) with 95% confidence intervals (95% CIs). Bootstrapping was used to calculate the 95% confidence intervals for the estimates.

To test for effect mediation, first the total effect of musculoskeletal pain on physical health (c path) was calculated. Then the extent of effect mediation attributable to social participation was examined by decomposing the total effect into a direct effect of baseline musculoskeletal pain on physical health (c′ path) and an indirect effect through social participation (a and b paths). The series of models consisted of an unadjusted model, followed by models incrementally adjusted for; 1) sociodemographic factors, 2) health factors (i.e. chronic limiting illness and baseline mental health) and 3) baseline physical health, to examine to what extent any effect mediation by social participation remained. Finally, factors identified as ways in which social participation influences subsequent health (i.e. physical activity, social support and a sense of purpose), were entered simultaneously as parallel mediators into the fully adjusted model to test for effect mediation, and whether any mediating effect of social participation persisted once that explained by these factors was accounted for in the model.

The extent to which social participation fulfilled the role of effect modifier was examined using a series of multivariable regression models with and without the addition of interaction terms. This was performed starting with an unadjusted model and then sequentially adjusting for: 1) age, gender and economic adversity, 2) health factors (mental health and limiting chronic illness), and 3) baseline physical health. Unlike in the mental health analyses multigroup analyses were not run after the initial probing of interaction terms as no significant interaction was identified. Instead all additional covariates identified in the theoretical model which informed the analyses were added to a final, fully adjusted single group model with and without interaction terms.

Finally, a series of sequentially adjusted multivariable regression models examining the total effect of baseline musculoskeletal pain on physical health, with and without inclusion of social participation as a predictor, were used to assess any confounding. The magnitude of confounding attributed to social participation was quantified by computing the difference between the initial and adjusted effect (in terms of the odds ratio) of baseline musculoskeletal pain on physical health, and dividing it by the adjusted total effect of musculoskeletal pain on physical health (Szklo & Nieto, 2014).

8.3.3 SENSITIVITY ANALYSES

Sensitivity analyses were run, using the same approaches detailed in Chapter Seven, to;

1) Test for potential bias due to exclusion related to missing data in the complete case analyses, by using full information maximum likelihood (FIML) to rerun the unadjusted and final, fully adjusted model including cases with missing covariate data. This was done for each third variable role.
2) Examine the extent of reciprocal causality in the relationship between social participation and physical health. An unadjusted, autoregressive cross-lagged panel model was used to examine reciprocal associations between social participation and physical health measurements at baseline and two-year follow-up using the mediation subsample.
3) Examine whether the cut-off for social participation affected the study findings. The unadjusted mediation model was rerun using two alternate methods of defining social participation. The first coded FreqHigh socialisers as 1, and all others

(i.e. infrequent, moderate and FreqLow) together as 0. The second method coded infrequent socialisers as 0, and all other socialisers as 1.

8.4 RESULTS: ANALYTICAL SAMPLES

8.4.1 DETERMINING THE ANALYTICAL SAMPLES

Of the 9432 individuals aged ≥50 years who returned a questionnaire at baseline, 261 participants were excluded. Detailed participant flow is provided in Figure 8:2. Of the 9171 respondents 1905 (20.8%) were missing baseline social participation information, leaving 7266 participants. Of those, 5872 (80.8%) provided complete self-reported health data at two-year follow-up. Exclusion of those with missing covariate data resulted in a loss of a further 769 respondents (768 of which were excluded as they had incomplete wealth data, and the other one respondent for missing baseline mental health data). Of the 5077 participants, 2782 (54.8%) provided complete physical health data at 4-year follow-up and social participation, sense of purpose, physical activity and social support data at 2-year follow-up and were the sample for the mediation analyses.

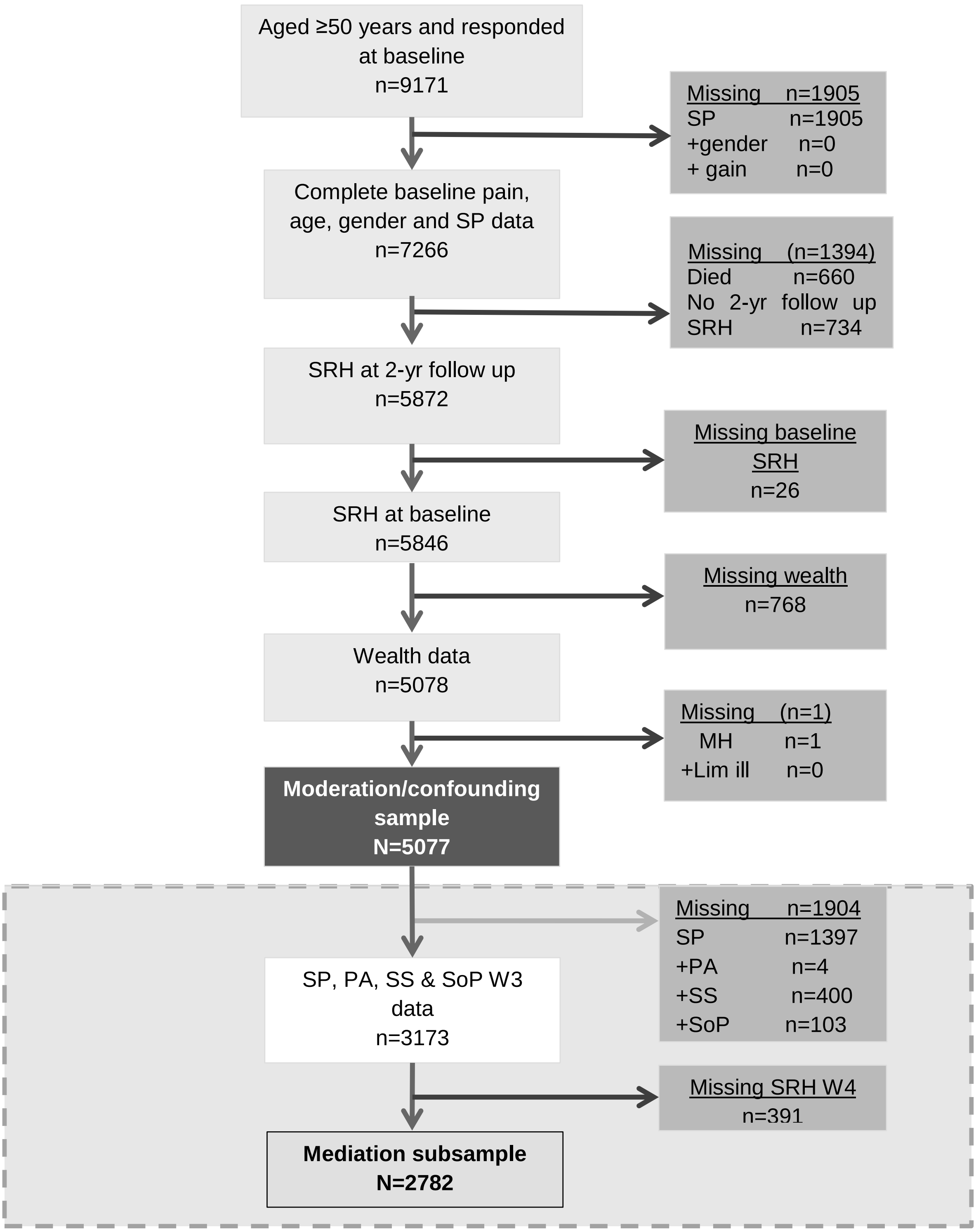

Figure 8:2 Flow diagram showing number of participants in the moderation sample and mediation subsample [14]

[14] SP= social participation, MH= mental health, SRH= self-rated health, Lim ill= limiting chronic illness, PA= physical activity, SS= social support, SoP = sense of purpose

8.4.2 COMPARISON BETWEEN MODERATOR/CONFOUNDING AND MEDIATION SAMPLES AND THE ENGLISH GENERAL POPULATION

Comparison between census data and the sample participants in the moderation/confounding sample (hence forth referred to as the 'moderator sample') and the mediation subsample are shown in Table 8:2. From observation, compared to the age and gender structure of the English population aged ≥50 years, the proportion of men and women aged ≥80 years was lower in the moderation sample (7.6%) and was lowest in the mediation subsample (4.8%). Compared to the English population (33.7%), there were more women aged 50-59 and 60-69 years in the moderation sample (39.1%), and mediation subsample (42.9%).

Table 8:2 The age and gender structure of the English population, the moderation sample and the mediation subsample

	English Population[15]		Moderation sample		Mediation subsample	
	Male	Female	Male	Female	Male	Female
50-59	17.6%	17.9%	15.7%	20.1%	17.1%	23.0%
60-69	15.1%	15.8%	16.3%	19.0%	16.3%	19.9%
70-79	9.5%	10.8%	9.8%	11.4%	8.7%	10.1%
80+	5.1%	8.3%	3.1%	4.5%	2.1%	2.7%
Total	47.2%	52.8%	44.9%	55.1%	44.2%	55.8%

[15] ONS Population estimates tool (2013 estimate)
http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/2013/index.html
Proportions shown are calculated using the total number of men and women in that group as a denominator

8.4.3 CHARACTERISTICS OF THE MODERATION/CONFOUNDING SAMPLE

The characteristics of ELSA respondents (providing complete data for that respective variable), the moderation sample and mediation subsample are provided in Table 8:4. The moderation sample was slightly younger (71.1% aged <70 years cf. 62.0% of overall ELSA respondents) and reported higher and more varied wealth (mean £304,000 cf. £265,000; SD 434,000 cf. 393,000) than ELSA respondents overall. Musculoskeletal pain prevalence was 1.7% lower in the moderation sample (35.5%) compared to overall ELSA respondents (37.2%). There was a similar distribution of men and women across the three groups. The moderation sample had slightly better overall health than the ELSA respondents overall, being more likely to report good physical health (78.0% cf. 72.2%), and less likely to report limiting chronic illness (31.5% cf. 35.4%) and poor mental health (27.1% cf. 31.0%). The characteristics of each social participation group within the moderation sample were examined, and are reported in Table 8:3. The proportion of people aged ≥70 was higher in the low socialiser group (39.9%) than the FreqLow socialisers (14.9%) and FreqHigh socialisers (28.7%). The prevalence of economic adversity in low socialisers was over three times as high as in each of the other two groups (34.9% cf. 9.0% and 8.6% in the FreqLow and FreqHigh groups respectively). Overall low socialisers also had poorest health, reporting a higher prevalence of musculoskeletal pain (44.0% cf. 28.1% and 30.4% in the FreqLow and FreqHigh groups respectively), and being more likely to report poor mental health (reported by 37.3% cf. 19.8% and 18.7% respectively). Limiting chronic illness was more prevalent in low socialisers than either FreqLow or FreqHigh socialisers (43.1% cf. 19.2% and 27.7%). At two-year follow up, good physical health was reported by 1222 (56.2%) of Low socialisers, 1402 (83.0%) FreqLow and 991 (81.7%) FreqHigh socialisers.

Comparison across each social participation group for those with and without musculoskeletal pain found the prevalence of good mental health at two-year follow-up to be 36.5% in Low socialisers with musculoskeletal pain compared to 71.7% in Low socialisers without musculoskeletal pain. In FreqHigh and FreqLow groups these prevalences were 66.7% cf. 88.3% and 66.9% cf. 89.3% respectively.

Table 8:3 The baseline characteristics of each social participation group within the moderation sample (n=5077)

		Low socialisers		FreqLow socialisers		FreqHigh socialisers		p-value
Total number		2175		1689		1213		-
Gender (female)		1161_a	53.4%	883_a	52.3%	753_b	62.1%	p<.001
Age (years)	50-59	578_a	26.6%	890_b	52.7%	350_a	28.9%	p<.001
	60-69	730_a	33.6%	548_a	32.4%	516_b	42.5%	
	70-79	593_a	27.2%	206_b	12.2%	280_c	23.1%	
	80+	274_a	12.6%	45_b	2.7%	67_c	5.5%	
Ethnicity (Caucasian)*		2139_a	98.4%	1671_a	99.0%	1201_a	99.0%	p=.198
Economic adversity		760_a	34.9%	152_b	9.0%	104_b	8.6%	p<.001
Musculoskeletal pain		957_a	44.0%	474_b	28.1%	369_b	30.4%	p<.001
Good physical health		1410_a	64.8%	1488_b	88.1%	1064_b	87.7%	p<.001
Limiting chronic illness		938_a	43.1%	325_b	19.2%	336_c	27.7%	p<.001
Poor mental health		1363_a	37.3%	1354_b	19.8%	986_b	18.7%	p<.001

a,b,c Subscript letters distinguish groups with significantly different proportions (p<.05)

Table 8:4 The baseline characteristics of the moderation sample, the mediation subsample and the overall ELSA sample who provided the respective data

		ELSA Respondents		Moderation sample		Mediation subsample	
Total number of older people		9432		5077		2782	
Gender (female)		5307	56.3%	2797	55.1%	1551	55.8%
Age (years)	50-59	2925	31.9%	1818	35.8%	1117	40.2%
	60-69	2920	31.8%	1794	35.3%	1008	36.2%
	70-79	2203	24.0%	1079	21.3%	525	18.9%
	80+	1123	12.2%	386	7.6%	132	4.7%
Ethnicity (Caucasian)*		9192	97.5%	5011	98.7%	2755	99.0%
Wealth £1000 (mean; sd)	[m=752]	265	393	304	434	346	493
Musculoskeletal pain		3505	37.2%	1800	35.5%	917	33.0%
Good physical health	[m=138]	6711	72.2%	3962	78.0%	2288	82.2%
Limiting chronic illness	[m=3]	3341	35.4%	1599	31.5%	789	28.4%
Good mental health	[m=275]	6321	69.0%	3703	72.9%	2131	76.6%
Social factors:							
Lives alone	[m=207]	2270	24.1%	1207	23.8%	580	20.8%
Weekly contact with others	[m=292]	6559	69.5%	4114	81.0%	2304	82.8%
Group memberships ≥2	[m=594]	2777	29.4%	1977	38.9%	1205	43.3%

Values are given as proportions (n), or mean (standard deviation) as appropriate. For ELSA respondents the proportion with missing data is given in square brackets [m=], only Ethnicity was missing for either of the other two groups (moderation sample m=3, mediation sample m=1)
Contact with others considers social network members defined as friends, relatives and/or family
Group memberships capture membership in one or more of seven distinct group types; social, political, neighbourhood, educational & art, religious, sport and charitable

8.4.1 CHARACTERISTICS OF THE MEDIATION SUBSAMPLE

Compared to ELSA respondents overall, the mediation sample were younger, reported greater wealth, were more likely to be frequent socialisers and reported better health (Table 8:4). They reported less musculoskeletal pain (33.0% cf. 37.2% of ELSA respondents), lower prevalence of limiting chronic illness (28.4% cf. 35.4%), and had 10% higher prevalence of good physical health, and almost 10% lower prevalence of poor mental health, than ELSA respondents overall. There were similar proportions of women (55.8% cf. 56.3%) in the mediation subsample. Finally, the social factors used for comparison showed that the mediation subsample were a little less likely to live alone, and over 10% more likely to have weekly contact with others (82.8% cf. 69.5%) with 43.3% of the older people in the mediation subsample members of ≥2 social groups, compared to approximately 38.9% of the moderation sample and approximately 29.4% of the ELSA respondents overall.

The mediation subsample participants were categorised as either: i) low socialisers at baseline and two-year follow-up, or reducing to low at two-year follow-up (‘infrequent socialisers’), or ii) being consistently frequent or increasing to frequent socialisers (‘frequent socialisers’). The characteristics of the two groups are described in Table 8 below. At four-year follow up, good physical health was reported by 613 (63.6%) of Low socialisers, 887 (87.0%) FreqLow and 703 (88.1%) FreqHigh socialisers.

Table 8:5 The baseline characteristics of each social participation group within the mediation sample (n=2782)

	Infrequent socialisers		Frequent socialisers		p-value
Total number	816		1966		
Gender (female)	452	55.4%	1099	55.9%	p=.806
Age (years) 50-59	214	26.2%	903	45.9%	p<.000
60-69	265	32.5%	743	37.8%	
70-79	249	30.5%	276	14.0%	
80+	88	10.8%	44	2.2%	
Ethnicity (Caucasian)	808	99.0%	1947	99.1%	p=.872
Economic adversity	253	31.0%	170	8.6%	p<.000
Musculoskeletal pain	367	45.0%	550	28.0%	p<.000
Good physical health	537	65.8%	1751	89.1%	p<.000
Limiting chronic illness	361	44.2%	428	21.8%	p<.000
Poor mental health	530	35.0%	1601	18.6%	p<.000
Sense of purpose (good)	415	45.3%	1512	20.9%	p<.000
Physical activity (high)	519	63.6%	1694	86.2%	p<.000
Social support (good)	494	60.5%	1367	69.5%	p<.000

** n=1 missing ethnicity data in this group.*

In the mediation subsample, compared to non-frequent socialisers those who were frequent socialisers were younger, with very few aged 80 and over (2.2% cf. 10.8%) and almost half (45.9%) aged 50-59 years, compared to approximately a quarter (26.2%) of non-frequent socialisers. There was no significant difference in the proportion of Caucasian people (both 99%; p=.872), however frequent socialisers were less likely to be categorised as facing economic adversity (8.6% cf. 31.0%). Frequent socialisers were less likely to report musculoskeletal pain at baseline (28.0% cf. 45.0%), and the prevalence of chronic illness was almost half that of the non-frequent socialisers (21.8% cf. 44.2%). Compared to the referent group in the moderation sample, the health of the referent group in the mediation sample (non-frequent socialisers) was similar in terms of prevalence of baseline musculoskeletal pain (45.0% in the mediation subsample referent group compared to 44.0% in the moderation sample), good physical health (66.4% cf. 64.8%) and poor mental health (35.0% cf. 37.3%).

8.4.2 CHANGE IN PHYSICAL HEALTH BETWEEN BASELINE AND FINAL FOLLOW-UP FOR THE MODERATION SAMPLE AND MEDIATION SUBSAMPLE

Approximately 15% of each analytical sample reported a change in physical health status between baseline and the respective outcome measurement (i.e. 2-year follow-up for the moderation/confounding sample and 4-year follow-up for the mediation subsample). At baseline 78.0% of the moderation sample (n=5077), and 82.1% of the mediation subsample (n=2782) reported good physical health. Overall participants reporting good physical health at baseline were highly likely to have maintained good physical health at the respective follow-up; with 84.7% of the moderation sample maintaining good physical health at 2-year follow-up, and 87.3% of the mediation subsample doing so at 4-year follow-up. Of those with poor physical health at baseline, approximately three quarters still reported poor physical health at the respective follow-up (76.9% of those in the moderation sample and 75.0% of those in the mediation subsample).

Table 8:6 Change in physical health status between baseline and outcome measurement for the moderation sample

N=5077	Moderation sample	
	Poor physical health (2yr)	Good physical health (2yr)
Poor physical health (baseline)	857 (16.8%)	258 (5.1%)
Good physical health (baseline)	605 (11.9%)	3357 (66.1%)

Table 8:7 Change in physical health status between baseline and outcome measurement for the mediation subsample

N=2782	Mediation sample	
	Poor physical health (4yr)	Good physical health (4yr)
Poor physical health (baseline)	369 (13.2%)	125 (4.5%)
Good physical health (baseline)	291 (10.4%)	1997 (71.7%)

8.5 RESULTS: THE ROLE OF SOCIAL PARTICIPATION

8.5.1 SOCIAL PARTICIPATION AS AN EFFECT MEDIATIOR

EXAMINING THE EXTENT TO WHICH SOCIAL PARTICIPATION IS AN EFFECT MEDIATOR

In the initial, unadjusted effect mediation analysis, frequent social participation was a weak but significant effect mediator of the association between baseline musculoskeletal pain and physical health four years later (Figure 8:3; p<.001). The total effect of musculoskeletal pain on physical health showed that reporting baseline musculoskeletal pain was associated with significantly reduced odds of good self-rated health at four-year follow-up (OR:0.19; 95%CI:0.16,0.24). When decomposed into direct and indirect effects explained through social participation, there was a significant indirect effect (p=<.001), but the odds ratio associated with reporting physical health between those with and without baseline musculoskeletal pain only reduced slightly (OR:0.22; 95%CI:0.18,0.27). In the unadjusted decomposed model, the odds of those with baseline musculoskeletal pain being a frequent socialiser were half that observed in those without baseline musculoskeletal pain (OR:0.48; 95%CI:0.40,0.56). However those who did maintain frequent social participation had four times the odds of reporting good physical health at four-year follow-up than those with musculoskeletal pain who reported infrequent social participation (OR:4.01; 95%CI:0.32,4.89). The natural indirect effect, given when musculoskeletal pain and social participation were reverse coded, suggested that those with baseline musculoskeletal pain who maintained frequent social participation had twice the odds of reporting good physical health at four-year follow-up than those with musculoskeletal pain who reported infrequent social participation (OR:2.01;95%CI:1.57,2.64).

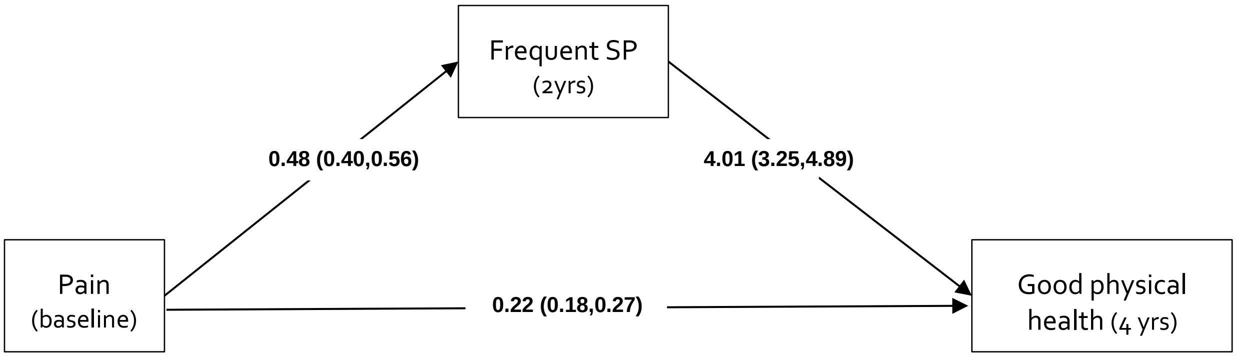

Figure 8:3 Path diagram illustrating the direct effect and causal paths linking musculoskeletal pain and good physical health. Results reported as odds ratio and 95% CIs

The total, direct and indirect path results for the series of sequentially adjusted models are provided in Table 8:8 below. In Model 2, after adjustment for age, gender and economic adversity, frequent social participation remained a significant, but weak mediator. Once chronic limiting illness and poor mental health were added (Model 3), the indirect path through frequent social participation was attenuated but remained significant (p=.169), but became insignificant with the addition of baseline physical health (Model 4; indirect effect OR:0.91, 95% CI: 0.74, 1.07; p=.267). The direct effect persisted, with reporting baseline musculoskeletal pain associated with half the odds of reporting good physical health at 4-year follow-up compared to reporting no musculoskeletal pain (OR:0.49; 95%CI:0.38,0.64). The association between baseline musculoskeletal pain and frequent social participation ('a' path) became insignificant (p=.880), but frequent social participation remained a strong predictor of subsequent good physical health at four-year follow-up ('b' path) in the fully adjusted model (OR:2.13; 95%CI:1.63,2.71). Frequent social participation at two-year follow-up was therefore a significant predictor of good physical health at four-year follow-up independently of baseline musculoskeletal pain status.

Of the other covariates included in the final, fully adjusted decomposed model, baseline physical health was the most influential, with good physical health at baseline associated with over seven times the odds of reporting good physical health at 4-year follow-up. Gender and age were not significantly associated with physical health at 4-year follow-up. However, economic adversity (OR:0.60; 95%CI;0.45,0.81), limiting chronic illness (OR:0.48; 95%CI:0.34,0.63) and poor baseline mental health (OR:0.61; 95%CI:0.47,0.80) were all significantly associated with reduced odds of maintaining physical health at 4-year follow-up.

Table 8:8 The total, direct and indirect effects of the association between musculoskeletal pain and physical health via social participation (SP) for the series of sequentially adjusted models (N=2782)

Path	Model 1		Model 2		Model 3		Model 4	
	Total Effect (c path)	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*
Musculoskeletal pain to physical health	0.19 (0.16,0.24)	0.22 (0.18,0.27)	0.20 (0.17,0.25)	0.22 (0.18,0.27)	0.38 (0.30,0.48)	0.38 (0.30,0.49)	0.49 (0.38,0.63)	0.49 (0.38,0.64)
Musculoskeletal pain to Frequent SP (a)		0.48 (0.40,0.56)		0.54 (0.45,0.66)		0.77 (0.63,0.96)		0.88 (0.71,1.10)
Frequent SP to physical health (b)		4.01 (3.25,4.89)		3.14 (2.50,3.88)		2.53 (1.98,3.16)		2.13 (1.63,2.71)
Indirect effect		0.36 (0.26,0.47)		0.50 (0.38,0.64)		0.79 (0.63,0.96)		0.91 (0.76,1.07)
Model fit*	-1279 (2)	-2835 (5)	-1218 (7)	-2620 (15)	-1104 (9)	-2490 (19)	-984 (10)	-2363 (21)
Baseline physical health on 4yr SR health							7.95 (5.96,10.30)	7.30 (5.46,9.49)

Results are given as Odds Ratios and 95% Confidence intervals

**Model fit is given as loglikelihood statistic (number of free parameters) smaller value suggests better fit*
Model 1 = Unadjusted model
Model 2 = Model 1 + adjustment for sociodemographic factors
Model 3 = Model 2 + adjustment for health factors (limiting chronic illness and poor mental health)
Model 4 = Model 3 + adjustment for baseline physical health
Shaded squares show ORs with 95% confidence intervals which are not significant at 5% level

EXAMINING SOCIAL PARTICIPATION EFFECT MEDIATION MECHANISMS; PHYSICAL ACTIVITY, SOCIAL SUPPORT AND A SENSE OF PURPOSE

The prevalence of physical activity, social support and a sense of purpose between infrequent and frequent socialisers for the mediation subsample were all significantly higher (p<.001) in the Frequent group. The difference was greatest for a sense of purpose (73.1% cf. 44.4%) and high physical activity (85.2% cf. 62.0%), whilst social support was reported by 73.1% of frequent socialisers and 64.2% of infrequent socialisers. When physical activity, social support and a sense of purpose were added simoultaneously as additional mediators in the multiple mediator model, three indirect pathways were significant; that of social participation (p<.001), physical activity (p<.001) and a sense of purpose (p<.001) in the unadjusted model (Figure 8:4). VIF values demonstrated acceptable colliniearity between all variables in the models (all values <5.0). The indirect pathway through social support was insignificant (p=.238). Maintaining frequent social participation despite baseline musculoskeletal pain was associated with just over half the odds of reporting good physical health compared to those with low social participation (OR:0.48; 95%CI:0.37,0.59). For high physical activity levels and a sense of purpose respectively the indirect effects were even stronger (physical activity OR:0.43; 95%CI:0.31,0.56 and a sense of purpose OR:0.38; 95%CI:0.28,0.49).

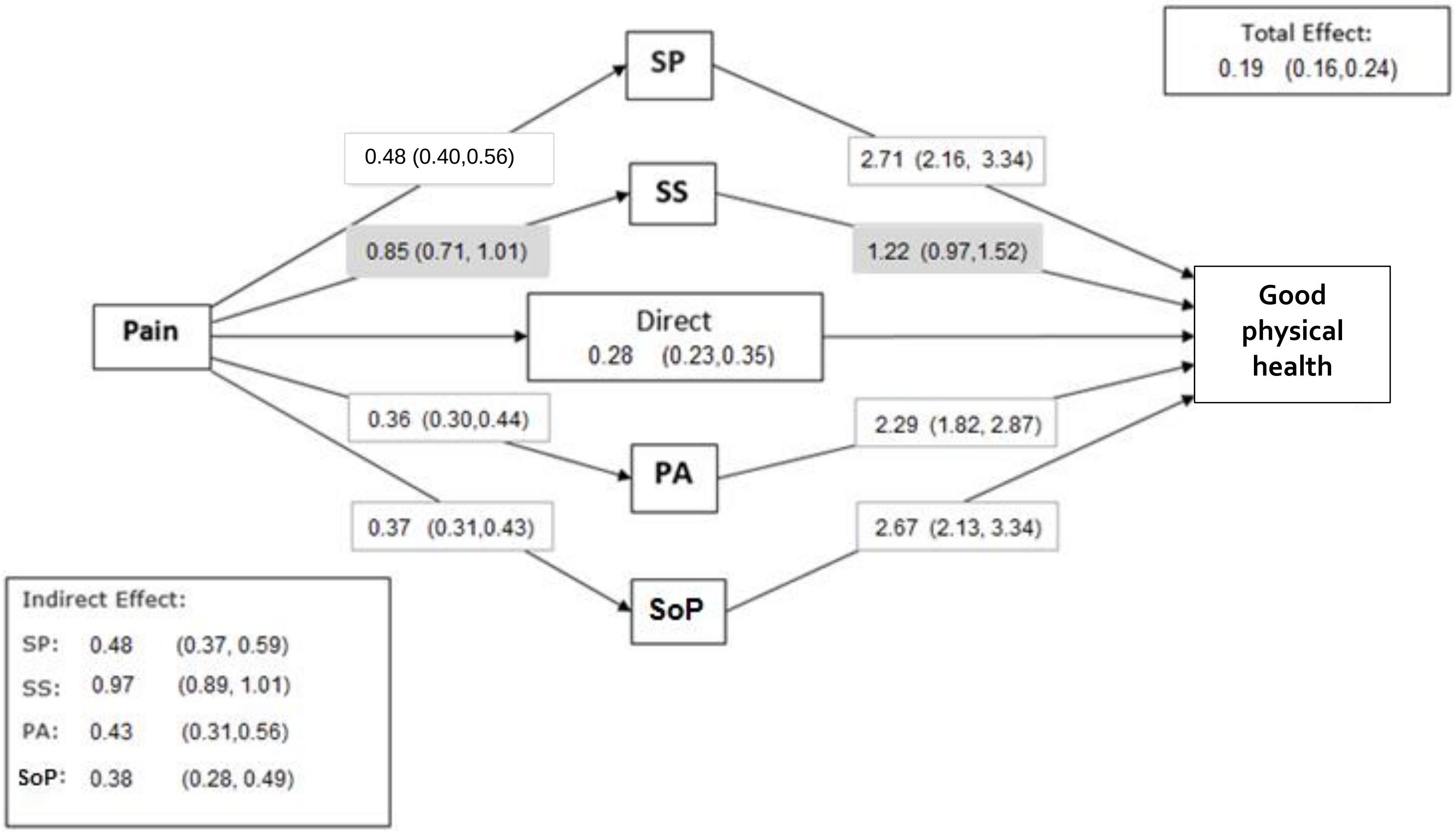

Figure 8:4 Path diagram of the unadjusted model examining the mediating effect of multiple mediators in the effect of pain on good physical health. Mediating variables are; social participation (SP), social support (SS), physical activity (PA) and a sense of purpose (SoP)

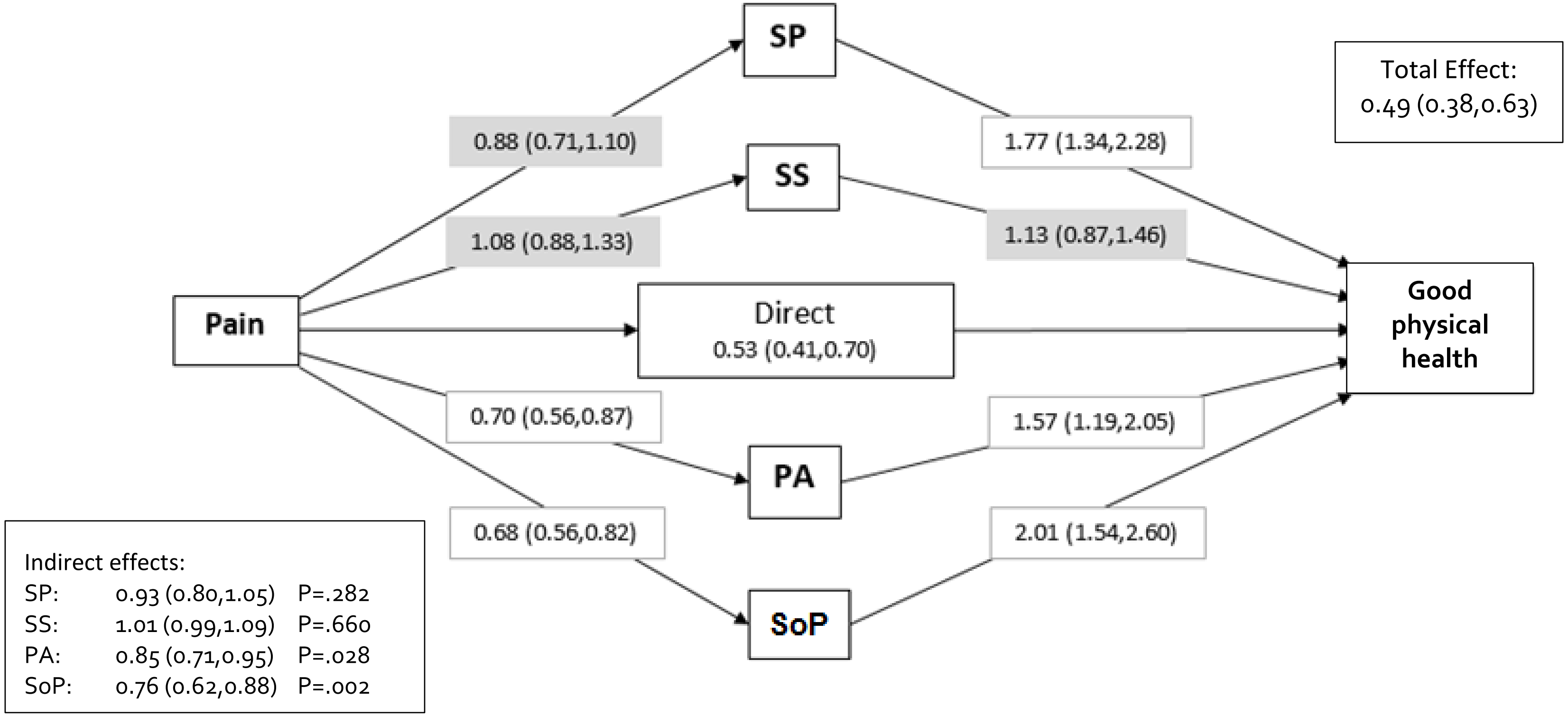

Figure 8:5 Path diagram of the fully adjusted model examining the mediating effect of multiple mediators in the effect of musculoskeletal pain on good physical health. Mediating variables are; social participation (SP), social support (SS), physical activity (PA) and a sense of purpose (SoP)

When all other covariates were adjusted for in the fully adjusted model, two indirect pathways remained significant; that of physical activity (p=.028) and a sense of purpose (p=.002). For the fully adjusted model, the a and b paths for the four mediators, as well as the direct and total effects are presented in Figure 8:5. Older people with musculoskeletal pain who maintained a sense of purpose had almost twice the odds of good physical health compared to those with musculoskeletal pain who were infrequent socialisers (OR:1.88, 95%CI: 1.436,2.44). For the indirect pathway through physical activity, those older people with musculoskeletal pain who maintained high levels of physical activity had odds of reporting good physical health of 1.18 (95%CI:1.05,1.41).

In the adjusted multiple mediator model, those with baseline musculoskeletal pain had lower odds of reporting a sense of purpose than those without musculoskeletal pain (OR:0.68, 95%CI:0.56,0.82), but those who did report a good sense of purpose had over twice the odds of reporting good physical health compared to those with poor sense of purpose (OR:2.67, 95%CI:2.13,3.34). The association between musculoskeletal pain and physical health remained (OR:0.53; 95%CI:0.41,0.70). Of the other putative mediators in the model, baseline musculoskeletal pain was predictive of subsequent levels of physical activity (p=.002) but not social support (p=.465). The association between baseline musculoskeletal pain and social participation also remained insignificant (p=.250). Frequent social participation and physical activity were associated with increased odds of subsequently reporting good physical health at 4-year follow-up (for social participation OR:1.77, and for physical activity OR:1.57) in older people, after adjusting independently for baseline musculoskeletal pain.

SENSITIVITY ANALYSES

How likely is bias due to missing data?

During the sensitivity analysis when the models were re-run using cases with missing covariate data, the association of baseline musculoskeletal pain with good physical health at 4-years was similar, with an unadjusted OR of 0.22 (95%CI:0.18,0.27) for complete cases and an OR of 0.24 (95%CI:0.20,0.29) when cases with missing covariate data were included. In the adjusted model OR estimates were also similar, and the same conclusions were drawn from the results (Table 8:9). However, in the adjusted model, there were differences in the odds ratios for the a and b paths, with the results of the missing-case analysis showing a shift towards the null for the a path (OR 0.88 to 0.97 in missing-case analysis), and away from the null in the b path (OR 2.13 to 2.26). The mediating effects of the four putative mediators included in the multiple effect mediator model using cases with missing data were similar between the complete case and missing data analyses, with no difference in the inferences made. For example, the OR for frequent social participation in those with musculoskeletal pain was 0.88 (95%CI:0.71,1.10) for complete cases and 0.96 (95%CI:0.82,1.20) when cases with missing covariate data were included. The direct effect of musculoskeletal pain on good physical health was very similar between complete case analyses (OR:0.53;95%CI:0.41,0.70), and cases with missing data (OR:0.58;95%CI:0.57,0.58). The results of the multiple effect mediator model using cases with missing data are reported in Appendix 7.

Table 8:9 Sensitivity analysis; Results of the complete-case (N=2782) and missing-data (N=7266) models for the unadjusted and fully adjusted total effects and decomposed models

Path	**Unadjusted model** *complete*		**Unadjusted model** *missing*		**Adjusted model#** *complete*		**Adjusted model#** *missing*	
	Total Effect (c path)	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*	*Total Effect (c path)*	*Direct/Indirect Effects*
Musculoskeletal pain to physical health	0.19 (0.16,0.24)	0.22 (0.18,0.27)	0.22 (0.19,0.26)	0.24 (0.20,0.29)	0.49 (0.38,0.63)	0.49 (0.38,0.64)	0.55 (0.46,0.67)	0.54 (0.46,0.65)
Musculoskeletal pain to Frequent SP (a)		0.48 (0.40,0.56)		0.55 (0.48,0.62)		0.88 (0.71,1.10)		0.97 (0.82,1.15)
Frequent SP to physical health (b)		4.01 (3.25,4.89)		4.13 (3.40,4.90)		2.13 (1.63,2.71)		2.26 (1.91.2.75)
Indirect effect		0.36 (0.26,0.47)		0.42 (0.35,0.51)		0.91 (0.76,1.07)		0.98 (0.86,1.11)

#Represents odds of good physical health in a case scoring 'o' on each variable in the model (e.g. in model I a male, aged 50-59, without economic adversity and engaged in a low amount of social participation activity)
#Adjusted model adjusted for sociodemographic and health factors and baseline physical health
Shaded squares show ORs with 95% confidence intervals which are not significant at 5% level

To what extent is the relationship between social participation and physical health recipriocal?

A sensitivity analysis was performed to examine the reciprocal relationship between social participation and physical health (Figure 8:6). Baseline social participation was a strong, significant predictor of physical health at two-years (OR: 2.43;95%CI:2.12,2.80), independent of the effect of baseline physical health (OR:14.56;95%CI12.52,16.81), and baseline social participation was a stronger predictor of social participation at two-years 14.56;95%CI12.52,16.81) than was baseline physical health (OR:2.52;95%CI:2.12,3.01).

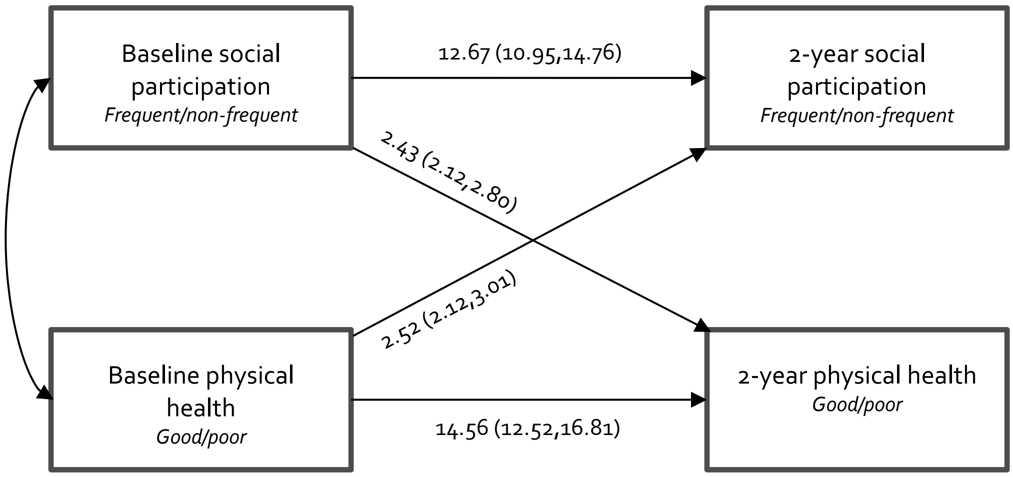

Figure 8:6 The reciprocal relationship between social participation and physical health at baseline and two-year follow-up. Results presented as ORs (95% CI)

Does the cut-off for social participation affect the study findings?

The basic mediation model was rerun using the two alternate cut-off values for dichotomising social participation. The association of baseline musculoskeletal pain with 'frequent' social participation at 2-year follow-up became weaker when the referent group included FreqLow socialisers (OR for the 'a path' went from 0.33 for infrequent versus all others, to 0.62 for FreqHigh versus others).

Next the association between social participation and good physical health was examined with social participation redefined using alternate cut-offs. As in the respective mental health sensitivity analysis, the association between social participation and the health outcome was weakened when using either alternate cut-point. When moderate socialisers were included with the two frequent socialiser groups, the OR for good physical health associated with social participation was 4.63 with a very wide 95%CI (1.15,23.4) which suggested an increase in the standard error (likley due to the small referent group size), and there was no significant indirect effect (p= 0.230). When FreqLow socialisers were combined with infrequent and moderate socialisers the association between social participation and physical health at four-year follow-up became weaker (OR:2.55:95%CI:2.03,3.22).

Does musculoskeletal pain severity influence the findings of any effect mediation?

When the distribution of musculoskeletal pain by severity was examined between social participation groups, a significant difference was found (p<.001) in the proportions with mild, moderate and severe pain. Of those with musculoskeletal pain in the Low socialiser group, 10.7% (n=103) reported mild pain, 57.1% (n=550) moderate pain and 32.3% (n=311) severe pain. In FreqLow socialisers these proportions were 11.4% (n=116), 72.5% (n=740) and 16.1% (n=164) respectively, and in the FreqHigh group 13.3% (n=106), 72.1% (n=575) and 14.7% (n=117). When the analyses were rerun, with those with mild pain excluded, the total effect of musculoskeletal pain on physical health was slightly stronger [OR:0.46 (95%CI:0.34,0.0.62) cf. OR: 0.49(95%CI: 0.38,0.63)] but overall there was no difference in the inferences drawn. The decomposed effects were no different in significance and similar in effect size to those of the main analysis. As in the original analysis, the indirect effect was insignificant [OR:0.82 (95%CI:0.0.64,1.02);p=.103], and the direct effect of musculoskeletal pain on physical health significant, with odds of good physical health lower in those with musculoskeletal pain [OR:0.47 (95%CI:0.35,0.64);p<.001].

8.5.2 SOCIAL PARTICIPATION AS AN EFFECT MODIFIER

TESTING FOR STATISTICAL INTERACTION

In the unadjusted analyses (Table 8.10; Model 1a), baseline musculoskeletal pain was negatively associated with good physical health at two-year follow-up (OR:0.24; 95%CI:0.21,0.27). FreqLow and FreqHigh social participation at baseline were both positively associated with good self-rated health at two-year follow-up. Compared to the low socialiser group, the FreqLow group had almost 3.5 times the odds of reporting good physical health (OR:3.40; 95%CI:2.90,3.98), and the FreqHigh group 3.2 times the odds of good physical health (OR:3.21; 95%CI:2.70,3.83).

The addition of interaction terms (Model 1b) identified no significant interaction between musculoskeletal pain and either the FreqLow (p=.694) or FreqHigh (p=.382) social participation. In the interaction model the OR for musculoskeletal pain remained constant, and those of FreqHigh and FreqLow slightly attenuated. After adjustment for age, gender and economic adversity (Models 2a and 2b) there was still no significant interaction between musculoskeletal pain and either frequent social participation group. Adjusting for poor mental health, chronic limiting illness and baseline physical health attenuated the association between musculoskeletal pain and two-year follow-up physical health, and there was still no significant interaction between musculoskeletal pain and social participation.

As estimates of association in models including interaction terms are difficult to interpret, the results from Model 3a (Table 8:10) were used to evaluate the associations between musculoskeletal pain, social participation, health factors (limiting chronic illness and mental health) and physical health measured at baseline. Baseline physical health was the strongest predictor of physical health at two-year follow-up (OR:7.74; 95%CI:6.35,9.34), followed by FreqHigh (OR:1.72; 95%CI:1.41,2.09) and FreqLow (OR:1.87; 95%CI: 1.51,2.33) social participation. A strong and negative association remained between baseline musculoskeletal pain and good physical health (OR:0.58; 95%CI:0.49,0.69). Female gender was associated with increased odds of good physical health (OR:1.30; 95%CI:1.11,1.54), and compared to the referent age group (aged 50-59 years) all other ages had significantly ($p<0.05$) reduced odds of reporting good physical health (for those aged 60-69 OR=0.77, 70-79 OR=0.57 and aged 80+ OR=0.61). The odds of good physical health were also less in those experiencing economic adversity compared to those who were not (OR:0.74; 95%CI:0.61,0.90). Reporting poor mental health at baseline was associated with almost half the odds of reporting good physical health 2 years later (OR:0.59, 95%CI:0.50,0.70) and having limiting chronic illness was the strongest negative predictor (OR:0.39; 95%CI:0.32,0.46).

Table 8:10 Physical health effect modification models with and without interaction terms. Results reported as odds ratios with 95% confidence intervals (N=5077)

	Model					
	1a	**1b**	**2a**	**2b**	**3a**	**3b**
Musculoskeletal pain	0.24 (0.21,0.27)	0.23 (0.19,0.27)	0.24 (0.21,0.27)	0.23 (0.19,0.27)	0.58 (0.49,0.69)	0.66 (0.52,0.83)
Social participation: FreqLow	3.40 (2.90,3.98)	3.30 (2.65,4.12)	2.62 (2.20,3.10)	2.50 (1.99,3.17)	1.72 (1.41,2.09)	1.96 (1.52,2.52)
Social participation: FreqHigh	3.21 (2.70,3.83)	2.97 (2.33,3.83)	2.63 (2.20,1.16)	2.45 (1.91,3.17)	1.87 (1.51,2.33)	2.04 (1.53,2.73)
Interaction: FreqLow x Msk Pain		1.07 (0.77,1.47)		1.10 (0.79,1.52)		0.74 (0.51,1.08)
Interaction: FreqHigh x Msk Pain		1.17 (0.82,1.66)		1.16 (0.81,1.65)		0.82 (0.54,1.24)
Gender (female)			1.22 (1.07,1.41)	1.22 (1.06,1.41)	1.30 (1.11,1.54)	1.31 (1.11,1.54)
Age (years) 50-59			1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
60-69			0.84 (0.72,1.00)	0.84 (0.72,0.99)	0.80 (0.64,0.93)	0.79 (0.64,0.93)
70-79			0.59 (0.49,0.71)	0.59 (0.49,0.71)	0.57 (0.46,0.71)	0.57 (0.46,0.71)
80+			0.59 (0.45,0.77)	0.59 (0.45,0.77)	0.61 (0.44,0.84)	0.61 (0.44,0.85)
Economic adversity			0.56 (0.48,0.66)	0.56 (0.48,0.66)	0.74 (0.61,0.90)	0.74 (0.61,0.90)
Poor mental health					0.59 (0.49,0.70)	0.59 (0.49,0.70)
Chronic limiting illness					0.39 (0.32,0.46)	0.38 (0.32,0.46)
Baseline physical health					7.74 (6.35,9.34)	7.78 (6.39,9.37)
Intercept#	2.47 (2.23,2.77)	2.53 (2.25,2.88)	3.58 (3.00,4.30)	4.33 (3.03,4.48)	1.07 (0.81,1.40)	1.00 (0.76,1.33)
Model fit*	-2609 (4)	-2608 (6)	-2561 (9)	-2561 (11)	-2064 (12)	-2062 (14)

Results are given as Odds Ratios and 95% Confidence intervals
Insignificant associations are shaded grey

*#Represents odds of good physical health in a case scoring '0' on each variable in the model (e.g. in model III a male, aged 50-59, without economic adversity and engaged in a low amount of social participation activity) | *Model fit is given as adjusted BIC; lowest aBIC is preferred | Model 1 = Unadjusted Model 2 = Model 1 + adjustment for sociodemographic factors (age, gender and economic adversity) | Model 3= Model 2 + chronic limiting illness, mental health and baseline physical health*

The sensitivity analysis examined cases with imputed missing covariates data, and yielded similar results (Table 8:11) so the findings of the complete case analyses were used for interpretation.

Table 8:11 Complete case and missing data results, with and without interaction terms, for the unadjusted and fully adjusted models

	Model 1b *complete*	**Model 1b** *Missing*	**Model 3b** *complete*	**Model 3b** *missing*
Musculoskeletal pain	0.23 (0.19,0.27)	0.23 (0.17,0.27)	0.66 (0.52,0.83)	0.59 (0.45,0.67)
Social participation: FreqLow	3.30 (2.65,4.12)	3.32 (2.57,3.98)	1.96 (1.52,2.52)	1.82 (1.32,2.59)
Social participation: FreqHigh	2.97 (2.33,3.83)	2.98 (2.27,3.69)	2.04 (1.53,2.73)	1.87 (1.50,1.23)
Interaction: FreqLow x Msk Pain	1.07 (0.77,1.47)	1.08 (0.87,1.65)	0.74 (0.51,1.08)	0.85 (0.61,1.37)
Interaction: FreqHigh x Msk Pain	1.17 (0.82,1.66)	1.21 (0.85,1.62)	0.82 (0.54,1.24)	0.96 (0.70,1.44)
Gender (female)			1.31 (1.11,1.54)	1.26 (1.04,1.47)
Age (years) 50-59			1.0 (ref)	1.0 (ref)
60-69			0.79 (0.64,0.93)	0.79 (0.70,0.93)
70-79			0.57 (0.46,0.71)	0.57 (0.48,0.68)
80+			0.61 (0.44,0.85)	0.64 (0.43,0.79)
Economic adversity			0.74 (0.61,0.90)	0.74 (0.60,0.86)
Poor mental health			0.59 (0.49,0.70)	0.59 (0.48,0.66)
Chronic limiting illness			0.38 (0.32,0.46)	0.39 (0.33,0.47)
Baseline physical health			7.78 (6.39,9.37)	7.47 (5.83,8.41)

Results are given as Odds Ratios and 95% Confidence intervals
Insignificant associations are shaded grey

#Represents odds of good physical health in a case scoring '0' on each variable in the model (e.g. in model III a male, aged 50-59, without economic adversity and engaged in a low amount of social participation activity)
**Model fit is given as adjusted BIC; lowest aBIC is preferred*
Model 1 = Unadjusted including only pain, SP and interaction terms
Model 2 = Model 1 + adjustment for age, gender, economic adversity, poor mental health, chronic limiting illness and baseline physical health

8.5.3 SOCIAL PARTICIPATION AS A CONFOUNDER

The findings from the confounding analyses suggest social participation is only a weak confounder of the association between baseline musculoskeletal pain and good physical health two years later, and this effect is lost when variation in age, gender, economic adversity, limiting chronic illness and poor mental health are accounted for (Table 8:12). In Model 1 there was a small (8.3%) proportion of confounding attributable to social participation, but the proportion of confounding was increasingly attenuated as other putative confounders were adjusted for, reducing to 4.2% in Model 2 (adjusted for age, gender and economic adversity), 2.2% in Model 3 (further adjusted for poor mental health and limiting chronic illness), and becoming 0.0% once baseline physical health was adjusted for. Thus it appears that any confounding was due to differences in the prevalence of the two health factors between social participation groups. Reanalysis using FIML to handle missing covariate data showed no differences between the proportion of change in the odds ratio of musculoskeletal pain with and without inclusion of social participation, and the conclusion of no confounding was maintained (Table 8:13).

Table 8:12 Incrementally adjusted models testing the role of social participation as a confounder of the association of baseline musculoskeletal pain and physical health at two-year follow-up (N=5077)

	Model 1	**Model 2**	**Model 3**	**Model 4**
Musculoskeletal pain on physical health Model fit*	0.22 (0.19,0.25) -2767 (2)	0.23 (0.20,0.26) -2649 (7)	0.45 (0.39,0.53) -2358 (9)	0.58 (0.49,0.69) -2087 (10)
Musculoskeletal pain on physical health with inclusion of social participation Model fit	0.24 (0.21,0.27) -2609 (4)	0.24 (0.21,0.27) -2561 (9)	0.46 (0.39,0.54) -2310 (11)	0.58 (0.50,0.69) -2064 (12)
Magnitude of confounding *(difference/adjusted OR) %*	8.3%	4.2%	2.2%	0.0%

Results are given as Odds Ratios and 95% Confidence intervals

**Model fit is given as adjusted BIC; lowest aBIC is preferred*
Model I = Unadjusted
Model II = Model I + adjustment for sociodemographic factors (age, gender and economic adversity)
Model III= Model II + adjustment for health factors (limiting long-term illness and poor mental health
Model IV = Model III + adjustment for baseline physical health

Table 8:13 Unadjusted and fully adjusted models, using complete cases only and then FIML of missing covariate data, to test the role of social participation as a confounder of the association of baseline musculoskeletal pain and mental health at two-year follow-up

	Model I *complete*	**Model I** *missing*	**Model II** *complete*	**Model II** *missing*
Musculoskeletal pain on physical health	0.22 (0.19,0.25)	0.22 (0.21,0.23)	0.58 (0.49,0.69)	0.45 (0.39,0.50)
Musculoskeletal pain on physical health with inclusion of social participation	0.24 (0.21,0.27)	0.24 (0.23,0.25)	0.58 (0.50,0.69)	0.45 (0.39,0.50)
Magnitude of confounding *(difference/adjusted OR) %*	8.3%	8.3%	0.0%	0.0%

Results are given as Odds Ratios and 95% Confidence intervals

Model I = Unadjusted
Model II = Unadjusted + adjustment for sociodemographic, health factors and baseline physical health

8.6 DISCUSSION

8.6.1 SUMMARY OF FINDINGS

This study has used a series of empirical analyses to test the role of social participation in maintaining physical health in older people with musculoskeletal pain. The findings are summarised in Table 8:14 below. The unadjusted results indicate that social participation is a confounder (i.e. distorting the true association) and an effect mediator (i.e. explaining why an association is observed) of the association between baseline musculoskeletal pain and subsequent good physical health in older people, but that it is not an effect modifier (i.e. does not affect the strength of association between musculoskeletal pain and physical health). However, once differences in sociodemographic, chronic limiting illness, mental health and baseline physical health status were adjusted for, no effect modification, effect mediation or confounding by social participation of the association between musculoskeletal pain and physical health remained (Table 8:14). As previously suggested (Umberson & Montez, 2010;Golden et al., 2009) social participation was a strong, independent predictor of subsequent physical health. Social participation and baseline musculoskeletal pain remained significantly associated, with reduced odds of good physical health identified at two-and four-year follow-ups in all adjusted and unadjusted models.

The multiple mediator analyses test whether any effect mediation persisted through social participation when social support, a sense of purpose and physical activity were included in the model. Results showed a significant indirect effect of musculoskeletal pain on physical health through social participation persisted in the otherwise unadjusted model. In the fully adjusted model a significant indirect effect existed through both physical activity and a sense of purpose, but not through social participation or social support. These findings suggest that a sense of purpose and physical activity both explain why some older people with musculoskeletal pain maintain their physical health even once putative confounders (i.e. sociodemographic factors, poor mental health and chronic limiting illness) are accounted for. Furthermore, the direct effect of musculoskeletal pain upon physical health persisted in the fully adjusted model suggesting these putative effect mediators alone do not fully explain the negative effect of musculoskeletal pain upon physical health in older people.

Table 8:14 Study findings: a summary of the role of social participation in determining physical health in older people with musculoskeletal pain

Analyses	Unadjusted analysis	Adjusted[1] analysis
Effect modifier: Social participation	No	No
Confounder: Social participation	**Yes**	No
Effect mediator: Social participation	**Yes**	No
Multiple effect mediators:		
Social participation	**Yes**	No
Physical activity	**Yes**	**Yes**
Social support	No	No
A sense of purpose	**Yes**	**Yes**

[1] Adjusted for age, gender, economic adversity, poor mental health, limiting long-term illness and baseline physical health

No evidence of social participation being an effect modifier of the association between baseline musculoskeletal pain and physical health at two-year follow-up was found, either in the unadjusted model or that adjusted for baseline physical health, sociodemographic and health factors. While initially, a small amount of confounding of the association between baseline musculoskeletal pain and physical health at two-years was found, other putative confounders better accounted for the observed difference in association strength and the proportion of confounding reduced to 0% in the fully adjusted model. Social participation was however a strong predictor in its own right of which older people with musculoskeletal pain will maintain physical health.

Overall, the findings suggest that although frequent social participation does not explain why some older people maintain physical health despite baseline musculoskeletal pain, maintaining social participation increases the odds of maintaining physical health in older people regardless of their pain status. Furthermore, helping older people maintain physical activity levels and a sense of purpose may increase the likelihood of an older person with musculoskeletal pain maintaining their physical health. However, methods to achieve this do not necessarily need to centre on social participation (e.g. physical activity may be achieved through activities performed alone such as jogging or swimming). Of all the independent variables, baseline physical health was the strongest single predictor of physical health at four-year follow-up, while baseline musculoskeletal pain reduced the odds of reporting good physical health by 20%. The implications of this study will be discussed in the next chapter.

8.6.2 COMPARISON OF FINDINGS TO PREVIOUS STUDIES

Of the five studies, identified in the systematic review (Chapter Four) only two captured physical health related outcomes. One examined insomnia onset (Tang et al., 2015), which is closely associated with mental health problems as well as being linked to other physical health conditions (Fernandez-Mendoza & Vgontzas, 2013), and the other examined self-rated health (Blyth et al., 2008). The studies measured social participation in both conceptually and methodologically different ways, neither of which were very comparable to this study, and they did not focus on physical health maintenance. Blyth et al., (2008) included a small subsidiary analysis testing if care-giving status modified the association between musculoskeletal pain and self-rated health. Tang et al., (2015), examined to what extent restricted social participation (and, additionally, physical limitation) was an effect mediator of the association between musculoskeletal pain and insomnia onset. Restricted social participation was defined by Tang et al., (2015) as the inability to perform one or more of a battery of functional activities which were representative of the broader construct of participation, as and when they wanted, some or more of the time.

Whilst this study found social participation not to fulfil any of the third variable roles once other putative confounders are accounted for, this was not the finding of the study by Tang and colleagues (2015). The Tang study found social participation was a weak effect mediator, however the social participation measure captured extent of restriction, rather than fulfilled activities, and measured the broader construct of participation according to the Levasseur model of social activities (Lavasseur et al., 2010). As described earlier in the thesis, social participation and social participation restriction are not polar opposites, and neither is physical health the polar opposite of having a health condition. Therefore, the path between musculoskeletal pain and insomnia examined by Tang and colleagues (2015) may be driven by different mechanisms to that between musculoskeletal pain and maintaining physical health. Consistent with other studies (e.g. Richard et al., 2009;Wilkie et al., 2007) this study found lower levels of social participation were associated with poor physical health and increased musculoskeletal pain.

A sense of purpose and physical activity were found to partially explain which older people with musculoskeletal pain maintained good physical health. The importance of a sense of purpose in determining health outcomes in older people is not novel, with social and productive activities shown to have physical health benefits in older people even when they involve little or no enhancement of fitness (Glass, et al., 1999). Maintaining a sense of purpose may be a useful goal for enhancing physical health in older people with musculoskeletal pain. Tang et al., (2015) considered effect mediation by physical limitation as well as social participation restriction. Tang et al., (2015) found the addition of physical limitation into the model to substantially attenuate the observed indirect effect of social participation restriction both in size and significance. Similarly, in this study, physical activity was a significant effect mediator. The benefits of physical activity to physical health in older people is known to include physiological markers such as lipid profile and reduced fat composition (Vogel, et al., 2009). Maintaining physical activity may be a better therapeutic target for maintaining physical health in older people with musculoskeletal pain. The lack of significance of the association between social support and physical health was unexpected, as previous studies of general populations have found social support to predict better physical health outcomes. However, the outcomes are predominantly cardiovascular in nature in these studies (e.g. Bowen et al., 2014; Uchino, 2006), and so may be determined by specific psychophysiological mechanisms which are not captured by the measure of physical health used in this study or may act over a longer time period (e.g. social support may act as a buffer to mitigate the potential impact of stressful events on cardiovascular factors such as blood pressure (Uchino & Kazdin, 2011; Uchino,2006).

This study found social participation was not an effect modifier of the relationship between musculoskeletal pain and physical health. Similarly, Blyth et al., (2008) found the relationship between musculoskeletal pain and poor self-rated health did not vary between care-givers and non-care-givers. The apparent lack of effect modification by social participation when determining which older people with musculoskeletal pain maintain physical health may explain, in part, why there is little evidence of studies examining this research area, as publication bias often results in under-representation of negative findings in published research databases (Szklo & Nieto, 2014).

8.6.3 STRENGTHS AND LIMITATIONS

As both the mental and physical health analyses followed a similar analysis plan, and utilised the same sampling frame, many of the methodological strengths and limitations of these analyses are the same as those reported in Chapter Seven. These include issues around the measurement and categorisation of concepts (e.g. social participation and musculoskeletal pain) and the constraints of secondary data analysis. The strengths and limitations pertinent to ELSA identified in Chapter Six (LCA) also apply with respect to the measurement of the social participation variable. These are not repeated here.

STUDY SAMPLE AND SUBSAMPLE

The response rate of the moderation sample and mediation subsample were acceptable, and slightly higher than the response rate of the comparable mental health sample and subsample. Once baseline participants who dropped out between waves or were missing necessary data were excluded, response in the moderation sample was 55.4%, and for the mediation subsample 30.3%, of the total sampling frame. Comparison with basic sociodemographic, health and social activity information collected at baseline for the entire ELSA sample showed nonresponse in the moderation sample and the mediation subsample was greater in the older, less affluent and least healthy individuals. The proportion of males was the same as for the mental health analysis, with the proportion of females across the three participant groups being 56%, 55% and 56% respectively. In terms of health, non-responders and those lost to attrition were more likely to have poor physical health, chronic limiting illness and poor mental health and also more likely to report baseline musculoskeletal pain. These differences mean that the role of social participation in the musculoskeletal pain to physical health association may be distorted towards the null, as less affluent, less healthy and older age groups are more likely to experience restricted social participation (Wilkie, et al., 2007), and these characteristics were also most likely in those who were infrequent socialisers (Chapter Six; description of health characteristics by social participation group).

Baseline low socialisers were most likely to be lost to attrition at two-year and four-year follow-ups. Of the 7266 older people assigned to social participation groups, 15% of frequent (i.e. FreqHigh or FreqLow) socialisers were lost from the moderation sample, increasing to 48% in the mediation subsample. For infrequent (i.e low or moderate) socialisers these proportions were 44% and 75% respectively. Furthermore, the proportion of each group who died or were institutionalised between baseline and two or four-year follow-up was proportionally greater in those who were infrequent socialisers at baseline. Therefore, it is likely that a number of those lost to attrition in the low and non-frequent groups did so as a consequence of reduced physical health. Those included in the mediation, moderation and confounding analyses were more likely to engage in frequent social participation than those who were lost to attrition, which suggests selection bias may impact on the results. However, sensitivity analyses were used to test for such potential bias arising from those with missing covariate data, and the age and gender distribution of the sampling frame and analytical samples were similar. The proportion of frequent socialisers in the moderation sample was similar to that reported in a Canadian population survey of adults aged 45 years and older (Ramage-Morin, et al., 2010), which defined frequent social participation as participating in community-related social activities at least weekly (57.2% cf. 59.8%).

PHYSICAL HEALTH

Only variables selected for inclusion in ELSA could be used in analyses, which were not specifically collected with this study research aim in mind. One limitation therefore was the scarcity of potential physical health outcomes which were theoretically linked to musculoskeletal pain and demonstrated sufficient change between waves. Whilst it did not relate to a specific physical health condition, self-rated health was a satisfactory measure of physical health for an exploratory study such as this. The difference between self-rated health and self-reported signs and symptoms is that the latter are descriptive in nature, while self-rated health is a multi-dimensional construct and is characterized as a personal judgment based on individual and social-normative criteria of priority to the respondent. However common methods of capturing signs and symptoms of physical health in health surveys are not free of subjectivity and bias. While self-report of condition diagnosis has been shown to be comparable to health record data for some conditions (e.g. diabetes), this is not always the case. In older people especially, expectations of poor health often lead to a failure to consult healthcare providers (e.g. deafness and falls are particularly under reported) (Barber, et al., 2010) which can lead to under-diagnosis or perceived normalisation, and thus non-reporting, of symptoms. Self-rated health has the advantage of not being contingent upon previous diagnoses and captures current health status.

There were strengths and limitations of using self-rated health as a measure of physical health. The primary limitation is that self-rated health is determined by many factors including favourable socioeconomic conditions, chronic conditions and mental and physical health (Damián, et al., 2008). However, even though self-rated health is a subjective measure, and captures both mental and physical health, it remains a useful proxy for physical health. It has been found to be an independent predictor of poor physical health outcomes (e.g. further morbidity and mortality) in older people across a range of studies even after adjusting for objective biological measures (Mavaddat, et al., 2014).

Other studies have reported that predictors of physical health are not identical to predictors of psychological health, suggesting differing aetiology (Pinquart & Sörensen, 2007). As self-rated health may be influenced by mood (Latham & Peek, 2013), baseline mental health was adjusted for in this study. An alternative strategy could have been to combine multiple indicators of physical health to construct a latent 'physical health' variable. However, as the other potential measures did not meet the criteria, there were few variables which could have contributed to such a measure.

8.6.4 COMPARISON OF THIS STUDY WITH THE MENTAL HEALTH OUTCOME STUDY

Mental and physical health were examined separately and reported in Chapters Seven and Eight. However, the analyses both drew participants from the ELSA cohort and followed the same methodological approach, enabling comparisons to be made across the two chapters. The descriptive characteristics of the two study samples showed that the prevalence of sociodemographic, social participation and health factors were very similar. Variations in gender, age, ethnicity, chronic limiting illness, musculoskeletal pain, mental health, physical health (defined as self-rated health) and social factors were all within 2% of each other. The proportion of Low, FreqLow and FreqHigh socialisers were also similar in both samples. For physical health the proportions were; Low=42.8%, FreqLow=33.3% and FreqHigh=23.9%, and for mental health; Low=41.2%, FreqLow=34.4% and FreqHigh= 24.3%. When change in outcome status between baseline and four-year follow-up was examined across the two studies, a similar proportion of the mediation subsamples maintained good health (71.7% in the physical health study and 72.7% in the mental health study). Change in health status (i.e. improvement or deterioration) between baseline and four years was greater in the mental health study (21.0%) compared to the physical health outcome (14.9%).

In unadjusted analyses, the difference in odds of good health associated with musculoskeletal pain (compared to the odds in those without pain) remained consistent across two and four-year follow-ups. The OR was stronger for physical health, with an OR of 0.24 (95%CI:0.21,0.27) at two-years, and 0.22 (95%CI:0.18,0.27) at four-years. For mental health the respective ORs were 0.35 (95%CI:0.31,0.40) and 0.34 (95%CI:0.27,0.45). In the fully adjusted models, the associations were attenuated but remained significant at both two-year and four-year follow-up for both outcomes. In both studies the baseline health outcome was the strongest predictor of status at follow-up. This association was stronger for physical health, with good physical health associated with over seven times the odds of maintaining good physical health at two years (OR:7.74;95%CI:6.35,9.34). For mental health, the odds of good mental health at two years were just over four time higher in those with good baseline mental health (OR:4.06;95%CI:3.46,4.74). Social participation remained a strong predictor of good mental/physical health two-years later in both studies. The difference in odds between FreqHigh/FreqLow socialisers and Infrequent socialiser socialisers was greatest for physical health (ORs:3.40 and 3.21 compared to ORs:1.96 and 2.04 in the mental health study).

When testing for effect mediation, both studies found that the association between musculoskeletal pain and social participation two years later became insignificant in fully-adjusted analyses, suggesting other factors (e.g. limiting chronic illness and existing mental and physical health) better explain this association. When additional mediators were added into the models, similar results concerning a sense of purpose as an important predictor of good health were found across both studies. In the fully adjusted physical health model the direct effect of musculoskeletal pain persisted, while for mental health it did not. Physical activity was not associated with good mental health two-years later, but was associated with good physical health, and partially explained the effect of musculoskeletal pain on physical health. It is possible that the benefits of physical activity to mental health are linked to an increased sense of self-efficacy and sense of purpose gained from participating. If this is the case then when both are included in the same model the best fitting would explain the majority of the effect. Social support was an important predictor of good mental health two years later, but was not a mediator of the association between musculoskeletal pain and good mental health, and was insignificantly associated with physical health. The results of the confounding analyses were similar across the two studies, with approximately 8% confounding of the association between musculoskeletal pain and the respective health outcome by social participation in the otherwise unadjusted analyses, reducing to 0% in both studies once all other putative confounders were adjusted for.

8.7 CHAPTER SUMMARY

This study contributes to the limited body of evidence examining the role of social participation in determining which older people with musculoskeletal pain maintain physical health. The findings suggest social participation to be an effect mediator of the association between musculoskeletal pain and physical health, and appears to be the first to focus specifically on good physical health as the outcome. The mediation effects attenuated to insignificance once putative confounders were adjusted for. Based on the findings of this study, physical activity and a sense of purpose appear to explain how some older people maintain their physical health. These factors may be important targets for interventions aiming to maintain health in older people both with and without musculoskeletal pain. While both may be accessed via social participation, the insignificant indirect effect through social participation suggests there are no characteristics intrinsic only to social participation which help maintain physical health.

CHAPTER NINE: DISCUSSION

9.1 CHAPTER OVERVIEW

This chapter summarises the findings of this thesis which examined the role of social participation in maintaining health in older people with musculoskeletal pain, and then critically discusses the assumptions made and the implications of the study findings, including recommendations for future research.

9.2 THE IMPORTANCE OF THE THESIS QUESTION

The Global Burden of Disease studies published in 2011 in the Lancet awoke the world to the fact that musculoskeletal conditions, most notably back and neck pain and osteoarthritis in older people, are the dominant cause of years spent living with disability (GBD, 2016). The most prominent musculoskeletal symptom is pain that persists over time. Such chronic pain is associated with disability, as measured by impact on people's daily lives, physical activities, physical and mental wellbeing, -and social and domestic life.

A major advance during the past 50 years in the way that persistent musculoskeletal pain is treated (ref to Waddell 'The Back Pain Revolution') means that many health practitioners no longer view such pain in isolation as an indicator only of some underlying pathology. Chronic musculoskeletal pain is now widely regarded as a complex mix of the biological, psychological and social - most specifically in relation to why it persists over time and the extent of its impact on people's daily lives. This shift in approach has produced practical approaches to help people get on with life despite the pain – focussing for example on rehabilitation approaches that mean that work can be comfortably undertaken even if the pain is not 'cured', and psychological approaches that help people understand how movement and activity help overcome the adverse consequences of persistent pain (Foster et al., 2018).

One overall outcome of these approaches is that the target for intervention ceases to be cure or obliteration of the pain per se (although this may be a reasonable outcome to pursue in some instances) but becomes the level of a person's perceived disability or restricted engagement with life. Improving these outcomes, as perceived and valued by the patients themselves, becomes the target for interventions.

However this still concerns the response of health care to ill people who have established chronic musculoskeletal pain. From gerontology and health promotion, a different formulation of the population problem posed by this condition has emerged: can we define musculoskeletal health in more positive terms? Concepts of healthy ageing and active ageing align with modern definitions of health (e.g. from the World Health Organisation (WHO, 2010)) as a positive state to be maintained rather than as an absence of disease or pathological abnormality. The relevance of this to musculoskeletal conditions relates to the sheer frequency and global ubiquity of these conditions, such that chronic musculoskeletal pain is the experience of most people at the oldest ages. Promotion of active healthy ageing has the potential to reduce the frequency and severity of the pain, and avoid the restrictions and interference with everyday life associated with chronic musculoskeletal pain in older people.

From a research perspective, if the high and increasing global burden of musculoskeletal conditions is to be contained and reduced, then targets for promoting healthy ageing that can achieve this must be identified sufficiently clearly and with strong enough supporting evidence to contribute to social and public health policy and investment, and to shift attention and investment away from the areas of unsuccessful medical activity. The studies described in my thesis aimed to investigate this approach to musculoskeletal pain in older people. It focused on the specific construct of social participation as one broad component of daily living that could causally and positively influence the consequences and the experience of musculoskeletal pain. This explains the rationale, importance and relevance of the main objective of my thesis – to investigate whether a causal link exists between active social participation and future physical and mental health (i.e. positive outcomes) in people with ongoing musculoskeletal pain.

9.3 SUMMARY OF THE STUDY FINDINGS

The overall aim of this thesis was to determine the role or roles of social participation in maintaining mental and physical health in older people with musculoskeletal pain. Three possible roles were considered, that of effect modifier, effect mediator and confounder. The thesis aim was examined using four research objectives, which were fulfilled using a comprehensive literature review and a series of quantitative analyses.

The review of the literature, reported in Chapter Four, was performed to systematically identify previous studies examining the role of social participation (either as a positive factor or in terms of social participation restriction) in determining health in older people. Despite using a broad, inclusive search strategy, only five studies were found that provided empirical evidence about the role of social participation (or a conceptually similar proxy measure) in determining health in older people with musculoskeletal pain. Overall, there was much inconsistency of measurement methods of all key constructs (i.e. social participation, pain and mental and physical health). None of the studies identified examined the positive role of social participation in maintaining mental and physical health, instead focussing on the role of social participation restriction and/or the onset of poor health. This gap in the available evidence base emphasises the need for and originality of this PhD study. Two papers examined social participation as an effect modifier, with only one finding restricted social participation to moderate the association between musculoskeletal pain and depressive symptoms. Four papers examined social participation as an effect mediator. Three found significant, partial effect mediation by social participation, one did not. Of the three studies reporting significant findings, one examined insomnia as the outcome of interest and the other two depressive symptoms. The limitations of the systematic review are presented and considered in full in Chapter Four.

A latent class analysis was performed to define groups of older people who share similar social participation characteristics, using data collected from a national cohort of older people as part of The English Longitudinal Study of Ageing. Four distinctive groups were identified based upon reported social participation activities. These were; 1) frequent socialisers with high levels of community engagement; 2) frequent socialisers with low levels of community engagement, 3) moderate socialisers; and 4) infrequent socialisers. Community engagement consisted of participating in various formal organisations or groups and voluntary work. The LCA groups distinguished cross-sectionally between different levels of health in older people. All groups were more likely to have better health and wellbeing than infrequent socialisers, with better health most strongly associated with the two frequent socialiser groups. The LCA provided an appropriate way to distinguish between study participants in the main analyses. The strengths and limitations of the LCA are presented and discussed in detail in Chapter Five.

The role of social participation in determining the association between musculoskeletal pain and subsequent mental and physical health in older people was tested using a series of multiple regression and path analyses (described in detail in Chapter Seven and Chapter Eight). In unadjusted analyses older people who participated in frequent social participation activities were over twice as likely to report good mental health two-years later (OR:2.40 and 2.28 respectively for the two frequent social participation groups; p>0.001), and over three times as likely to report good physical health two-years later (OR:3.40 and 3.21 respectively for the two frequent social participation groups; p>0.001). In all analyses, social participation remained a strong predictor of subsequent good mental health and good physical health, independent of musculoskeletal pain status and other putative confounders. These findings support those of other studies (e.g. Chiao et al., 2011; Holmes & Joseph, 2011;Croezen et al., 2009) which have found social participation to be a strong independent predictor of maintaining good health, even when musculoskeletal pain, existing health status, environmental and personal factors are accounted for.

Frequent social participation partially explained (i.e. was a partial effect mediator) why some older people with musculoskeletal pain maintain good mental health (OR: 0.52:95%CI:0.38,0.67) and good physical health (OR: 0.50:95%CI:0.38,0.64). These effects remained after adjustment for age, gender and economic adversity, but became insignificant in both instances after adjustment for baseline mental and physical health and chronic illness. In unadjusted analyses, the effect modifying effect of social participation was insignificant ($p=.382$) in determining physical health in older people with pain, but was weak and significant for mental health ($p=.014$). After adjustment for putative confounders (i.e. sociodemographics, baseline health status and chronic limiting illness), only the role of effect mediator of the association between musculoskeletal pain and good mental health remained statistically significant (OR: 1.46; 95%CI:1.12,1.91). In these fully adjusted models, the role of effect modifier for both mental and physical health and effect mediator for physical health were all insignificant ($p>.010$). Social participation was a weak confounder of the association between musculoskeletal pain and good mental health (8.6%) and physical health (8.3%), but in both cases the proportion of effect attributed to confounding by social participation reduced to 0.0% following adjustment for other putative confounding factors.

Social participation is a means of accessing social support, physical activity, and a sense of purpose (Piškur et al., 2014;Richardson et al et al., 2014;Caetano et al., 2013;Golden et al., 2009). To further understand how and why social participation may explain why some older people with musculoskeletal pain maintain mental and physical health, this thesis examined these three constructs as additional, parallel effect mediators of the association between musculoskeletal pain and mental and physical health. A sense of purpose was a strong and significant effect mediator of mental and physical health, partially explaining why some older people with musculoskeletal pain retain health. Which older people with musculoskeletal pain maintain good physical health was also partially explained by physical activity. Physical activity was not a significant effect mediator in the mental health analyses, and social support was not a significant effect mediator in either analysis. These findings demonstrate that 'sense of purpose' and physical activity are important for maintaining health in older people with musculoskeletal pain, supporting the findings of studies in more general populations (Windsor et al., 2015;Kim, et al., 2014;Friedman & Ryff, 2012;Smith & Zautra, 2000).

9.4 ORIGINALITY OF THE THESIS

The originality of this thesis includes the basic approach to the study aim, as well as methodological aspects of the thesis (which relate to the use of English Longitudinal Study of Ageing (ELSA) cohort data and are discussed in more detail in the Section 9.4 below). The basic approach to the thesis was novel in that:

i) it examined frequent social participation as a positive factor of interest in older people with musculoskeletal pain, rather than focussing on social participation restriction;

ii) it examined good mental and physical health as the outcomes of interest, rather than seeking to explain the onset of poor health, and;

iii) latent class analysis (LCA) was used to develop an original measure of social participation from the ELSA dataset.

Studying the positive role of social participation, rather than negative implications of social participation restriction, was identified as an important factor during the study design. Social participation fulfilment and restriction are not two ends of the same continuum. Those who are unrestricted may still actively choose not to pursue certain aspects of social participation, and those who have functional limitations may not necessarily experience disability (Shakespeare & Watson, 2002). Empirical evidence identified during the systematic literature review supported the hypothesis that social participation may influence health by different mechanisms to social participation restriction, rather than being opposite aspects of a single construct (Mavandadi et al., 2007; Parmelee et al., 2007). Social participation is a normal aspect of daily life, so understanding how it may positively contribute to health maintenance in older people with musculoskeletal pain is important.

The benefits of maintaining social participation are well established in general older populations (Cornwell & Waite, 2012; Barth et al., 2010;Forsman et al., 2011). However, this empirical study is the first to examine the role of social participation specifically in older people with musculoskeletal pain, the most frequent cause of disability in daily living in this age-group. Understanding the mechanisms underlying social determinants of health has been identified as a necessary priority to further understanding of how to maintain public health (Braveman & Gottlieb., 2014). This study is the first to examine the effect mediating role of three possible factors which may be accessed through social participation activities. These factors (a sense of purpose, physical activity and social support) have been identified as benefits accessed through social participation activities (Windsor et al., 2015;Berkman et al., 2000), and may explain why social participation predicts good health.

Examining maintaining good health as the outcome of interest, rather than onset of poor health or morbidity, was identified as an important aspect of the research question during the early developmental stages of the thesis. When examining existing conceptual models underpinning the role of social participation in determining which older people with musculoskeletal pain *maintain* their health, it was identified that different underlying mechanisms are likely to be at play than those underlying health deterioration. For example, while this thesis suggested a sense of purpose was extremely important in maintaining health in older people with musculoskeletal pain, little evidence can be found which concludes that lack of a sense of purpose *causes* poor health (although it is known to be correlated), and equally, a sense of purpose can persist concurrent to poor health (Elliot, 2016). Factors which promote good health are therefore not necessarily the opposite of those which drive health deterioration. This is important within the field of Primary Care research as preventative interventions are conceptually different from curative ones, and public policy increasingly emphasises health promotion in older age (HM Government, 2010b; WHO, 2002). Consequently, research focussing on mechanisms underlying health maintenance is highly relevant. A focus on musculoskeletal pain was important as, in older people especially, disability and poor health associated with musculoskeletal pain is a major challenge both within the UK and globally (Croft et al., 2010;Docking et al., 2015). Currently there is a futility in trying to cure musculoskeletal pain for many older people (Mallen et al., 2013;Croft et al., 2010), and so potential for reducing or preventing the impact on older people's lives is more likely to come from focussing on promoting good health and reducing the burden of musculoskeletal pain on daily life (Moore et al., 2014;Jordan et al., 2012;Buchman et al., 2010).

The Latent Class Analysis (LCA) identified social participation profiles that are a useful starting point for those wishing to examine the role of social participation, rather than social participation restriction. Living a long and healthy life is a key research priority theme in the current UK Medical Research Council strategic plan (MRC., 2014), with specific focus on influential behavioural and environmental factors. The use of LCA to categorise participants according to their social participation activities is an original contribution to this priority, as previous empirical studies tend to capture social participation using linear scales, rather than a nominal variable based upon multidimensional profiles, and they predominantly focus on the extent of restriction (WIlkie et al., 2013;Magasi & Post, 2010). Using LCA enabled a multi-dimensional measure to be developed from a battery of markers, capturing one or more aspect of social participation activities. Variables developed using LCA are data driven (Clark & Bengt, 2009) meaning that the characteristics of the classes in the identified measure were informed by naturally arising patterns of variation in social participation activity found between older people, rather than being driven by a priori hypotheses of the researcher. Consequently, the resulting group characteristics provided additional insight into the key differences between the social participation profiles of older people at a population level, and the associated health and sociodemographic characteristics.

9.5 CRITICAL REFLECTION ON THE MAIN STUDY AND ANALYSIS

The use of ELSA is a fundamental characteristic of this study (described in detail in Chapter Five), and as such characteristics of ELSA underpin the overall strengths and weaknesses of the empirical findings. ELSA was selected as the data source as it provided a large, longitudinal dataset collected from a nationally representative cohort of older people. The ELSA cohort was purposely established to provide a comprehensive dataset of high quality longitudinal data that can be used in health and social research of older people (Steptoe et al., 2012). As such many of the variables available are collected using established, validated measures of the respective constructs. ELSA was selected as it provided the most comprehensive, freely available dataset specifically collected to be representative of the English older population. A strength of secondary data analysis is that it increases cost efficiency and reduces the amount of time necessary to undertake research. However, there are also weaknesses and limitations when using a dataset such as ELSA for the types of analysis described in the thesis.

The study design sought to follow best practice in terms of examining effect mediation and effect modification. Secondary data analysis of data previously collected as part of ELSA enabled three waves of data from the same cohort to be used to examine effect mediation and effect modification. For effect mediation especially, the use of appropriate longitudinal data is a fundamental when examining the causal pathway between a predictor and outcome (Hayes, 2013). Baseline measures of the mediator and outcome variable are needed to control for baseline values so as to isolate the effect of the proposed mediator (Hayes, 2013). The use of cross-sectional data is a well-documented limitation of many empirical studies of effect mediation (Lui et al., 2015; Imai et al., 2011), and the use of such data does not satisfy the necessary assumptions required to identify causal effect estimates (Lui et al., 2015).

During analysis many of the variables were dichotomised. This facilitated ease of interpretation (e.g. effect of pain versus no pain, or factors associated with good health versus not having good health). However, the resulting loss of information means the interpretation of the mediating effect of social participation in the association between musculoskeletal pain and good mental and physical health lacks detail, and the loss of information may have led to an under- or over-estimate of the true effect. However, as this is an exploratory study, and very little empirical evidence of the role of social participation in determining which older people with musculoskeletal pain maintain their health is available, the findings make a useful contribution to the evidence base.

One of the limitations of secondary data analysis is that the questions that can be asked on a particular topic have to be framed and shaped by the available data. A description of the variables selected and reasoning for selecting some and omitting others is provided in Chapter Five. Briefly, putative confounding variables were selected if they met the following criteria: the criteria for confounding was met (described in Section 3.4.1 of thesis), they were not identified as 'colliders' when considered using DAG theory (Appendix 1), and data capturing the construct was available in the ELSA dataset. For example, ethnicity was not included as a putative confounder as there was insufficient variance in the distribution among the groups being compared. Adjusting for unnecessary confounders can reduce the statistical power of analyses and introduce additional bias (Groenwold, et al., 2011), while neglecting to adjust for confounding factors can introduce bias and lead to inaccurate results (Szklo & Nieto, 2014). Therefore, the models used for analysis were informed by robust theoretical underpinnings and empirical evidence.

Some assumptions were made when selecting suitable variables for the constructs of interest. These were presented and examined empirically in Chapter Five. For example, responses reporting 'troublesome pain' were assumed to predominantly capture pain of musculoskeletal origin. This variable was selected as the ELSA dataset did not contain information regarding location or specific source of pain, but asked participants if they were 'often troubled' with pain. It has been suggested this measure of pain may be an underrepresentation of the construct of pain as a positive response may only be forthcoming if pain is significant enough to be considered frequent (Reyes-Gibby et al., 2002). Furthermore, this way of assessing musculoskeletal pain may capture the presence of non-musculoskeletal pain, as well as failing to capture the presence of 'non-troublesome' musculoskeletal pain. Empirical analyses were therefore carried out to test the assumption that the variable captures primarily musculoskeletal pain and these supported its use. However, it is possible a small number of participants were misclassified.

The age and gender distribution was comparable to those of the English older population (ONS, 2014). Levels of non-response and attrition in ELSA were comparable to other similar cohort studies (Marmot et al., 2003). The main reason for non-response to the first wave of ELSA was refusal to take part (Cheshire et al., 2012). Other reasons were language difficulties, absence during the survey period or illness and/or physical or mental difficulties preventing individuals from taking part (Cheshire et al., 2012). Non-response to some elements of the interview was minimised during data collection through a system of 'unfolding brackets', allowing respondents to make range-restricted estimates when they did not have exact information (Steptoe et al., 2013).

Non-response bias is a form of selection bias where the participants who don't respond in a study differ from those who do (Bowling, 2014). For example, those who had significant health problems or lower levels of literacy may have been less likely to choose to take part in ELSA than those who did not, reducing the generalisability of the study findings. This is less important for the analyses in this thesis which are an investigation of associations **within** the ELSA cohort, but non-response at baseline may limit the variability in the cohort and reduce power to identify true associations. However, the distributions in our baseline data, and in the many other published analyses of ELSA data, indicate this would not be a major source of bias. There was sufficient variability within the sample to allow estimates of effect to be made.

One example in the thesis of where selective non-response may have occurred concerns the constructed variable for social participation, using latent class analysis. This variable drew on social participation questions which were more frequently unanswered compared to other parts of the ELSA survey. The group reporting infrequent socialising was small. Infrequent socialising is linked with poor health generally, and it may be that those with poor health were less likely to complete the survey fully (ref). Since the thesis adopted an analysis which only used cases with complete datasets, it is possible that there was selective exclusion of people with poor health who were infrequent socialisers. This would be unlikely to change the nature of the latent class clusters but might alter the relative frequencies of people in each cluster. One practical outcome of the small numbers was that the infrequent and moderate socialiser subgroups were combined for the analysis. This might dilute any associations between infrequent socialising, pain, and health. Despite this possibility, associations were observed between participation and health and between participation and chronic musculoskeletal pain.

More importantly, however, bias in cohort studies can also arise from attrition, which occurs when participants followed over time fail to respond at later time points and so leave the study early without providing data for the final waves. If those lost differ from those who remain in the study, any observed association will be an overestimate or underestimate of the true effect. Participants in empirical analyses were more likely to be female and younger than non-participants, and those lost excluded due to missing data were more likely to report poor health and infrequent social participation. Although statistical methods were used to control for these differences in statistical analyses, and the levels of attrition for participants were consistent with those of previous research, and publications on attrition in cohort studies have estimated the risk of bias to be small (Lacey et al., 2013). It is possible that such selectivity in follow-up influenced our findings. Estimates of association might be biased towards the null if the sample selectively lost people with poor health and infrequent social participation who had worse outcomes than those with similar characteristics who remain in the study. This is possible since poor response at follow-up itself may indicate selectively worse health and be one explanation of the low effect estimates observed in this analysis.

One example of the potential influence of missing data is in the mediation analysis, A strength of the ELSA data and the sample used in this thesis is that there were three time points available for constructing the mediation analysis. However this meant more occasions for missing data to occur. Since the analysis only used responders with complete datasets across the three occasions, there was an increased likelihood of participants being excluded. If healthier, more positive participants were more likely to provide a complete dataset, then real associations might have been diluted. Although results were similar when participants with missing data were included in a separate sensitivity analysis, it is possible that the negative findings of the mediation analysis might reflect dilution of effect because of selective loss of participants with lower social participation.

To examine the likelihood of non-response bias the characteristics of respondents and non-respondents were compared to the English general population in terms of age and gender. Participants in empirical analyses were more likely to be female and younger than non-participants, and those lost because of attrition were more likely to report poor health and infrequent social participation. The levels of nonresponse and attrition were consistent with those of previous research, and statistical methods were used to control for the differences in the analyses. Additionally, sensitivity analyses were used to compare results from those providing complete data, to results yielded when missing data was estimated using full information maximum likelihood models.

The constraints of using secondary data analysis mean some factors which could have further informed the analyses were not studied because they are not included in ELSA data. For example, a limitation of the social participation measure extracted from ELSA is that it does not account for an individual's subjective appraisal of their social participation, which may affect the way an individual's social participation activities influence their health. Loneliness, or dissatisfaction with one's social network size, and unmet social needs, were not considered in this study, yet have been shown to influence health (Burholt, & Scharf, 2014; Cacioppo et al., 2006). Another example of a domain not covered in the analyses in this thesis is provided by environmental factors which can promote or impede social participation in older people. Reduced mobility in older age (e.g. loss of driving license or difficulty walking long distances) is common (Charles & Carstensen, 2010), and this can result in increased reliance on public services to access and initiate social activities. The absence of, or changes in, socio-structural factors (i.e. relocation of shops and services or absence of parks and community spaces), lack of support (from both social network members and service providers) and difficulty getting around are also associated with reduced social participation (Levasseur et al., 2015). Such constructs are often significantly, and strongly associated with social participation patterns in older populations (Goll et al., 2015; Bowling & Stafford, 2007). In this study, socioeconomic factors were crudely adjusted for by using a single measure to identify socioeconomic adversity as this was the most suitable variable available. ELSA did not capture suitable data to enable dependence on use of public transport, or access to transportation. While number of cars per household and use of public transport were captured, these measures did not reflect whether or not an individual had good access to their transportation of choice. Infrequent use of public transport might indicate lack of accessibility, or lack of desire to use it.

Examining mental and physical health as separate outcomes was an important and original aspect of this thesis. It may be considered controversial however, considering the difficulties in separating each of these aspects of health from the other. While it is impossible to totally disentangle mental and physical health into two independent entities

(Age UK, 2014;Birchera & Kuruvilla, 2014), it was demonstrated in this thesis that the measures (depressive symptoms and self-rated health) were suitable for distinguishing mental and physical health respectively. Considering each aspect of health separately is particularly advantageous for informing understanding and research of how specific health outcomes might be influenced by social participation. For example, the findings of this thesis suggest that clinical trial interventions to maintain physical health via social participation should incorporate elements of physical activity, whereas for mental health outcomes the physical activity element may not be a priority.

The final issue concerns the generalisability of ELSA and of the results of the analyses conducted in this these which drew on the ELSA database. The age and gender distribution of ELSA was comparable to those of the English older population (ONS, 2014). The prevalences of musculoskeletal pain, frequent social participation and mental and physical health were broadly similar to the findings of previous general population studies involving participants of similar ages, suggesting that the study population was representative of the general older population more generally. When compared to infrequent social participation, frequent social participation was shown to be robustly associated with greater odds of good mental and physical health in all empirical analyses. The consistency of this association suggests it is highly likely to be generalisable to the general older population. In the effect modification and effect mediation analyses, some social participation groups were combined to ensure optimal group sizes for analysis. Large differences between group sizes, or very low numbers in groups, can negatively affect the power of analyses (Masyn, 2013), meaning a greater effect size is required for the null hypothesis to be rejected in the presence of a true effect. Tests of effect modification and effect mediation are highly influenced by how variables are defined and coded (Hayes, 2013), and so although sensitivity analyses demonstrated consistent findings across complete-case and missing-case analyses, different findings may be found using different definitions and coding practice. As previously described, social participation activities differ between men and women (Culph et al., 2015; Luo et al., 2012; Stelle et al., 2010) and further research is needed to test the validity of the findings of this thesis when applied to single sex samples. Overall, the similarity and consistency of the findings across study components and within previous research would suggest that the novel findings of this research would be applicable to the general population.

9.6 WHAT NEEDS TO BE DONE TO ADVANCE UNDERSTANDING

This study was limited by the use of secondary data analysis of existing data collected as part of ELSA. The ELSA cohort is intended to be representative of the English older population, but its limitations have been considered in the previous section. Social participation is strongly driven by cultural and environmental factors (Dahan-Oliel et al., 2008;Bukov et al., 2002), so may manifest in quite different activities in other populations. Further empirical testing of the relationship between social participation and physical health is particularly needed, to help determine the underlying mechanisms, and explore whether this is a general effect or specific to certain physical health outcomes. This could be done using other existing cohorts such as The Irish Longitudinal Study on Ageing[16] and the Study of Ageing Survey on Health and Well Being of Elders[17].

Further epidemiological studies, both cohort studies and case-controlled studies, should explore other longitudinal associations between social participation and good health in older people with musculoskeletal pain. A good starting point for future epidemiological studies would be to look at cardiovascular health outcomes, as a body of work has previously linked social support, another primary aspect of social participation, to cardiovascular health (Bowen et al., 2014;Rodríguez-Artalejo et al., 2006; Uchino, 2006).

Comparison to other similar studies suggests that the number of distinctive 'groups' which can be distinguished in terms of social participation activities differs depending upon the observed indicator items used and the population being studied (Crozen et al., 2009; Hong et al., 2009). There are strong similarities between these studies, but no consensus on the exact number of distinctive groups (they range from 3 to 5). Further studies are needed to validate the four groups identified in this study across other similar general older population samples, and test whether they manifest consistently across specific sub-groups of older people, such as only those with musculoskeletal pain. This should include empirical analyses using participants with differing levels of social participation and in different older populations (e.g. older adults living in rural areas). Measurement invariance testing could be used to examine if the four-class model identified in this thesis fits other

[16] https://tilda.tcd.ie/
[17] https://www.icpsr.umich.edu/icpsrweb/DSDR/studies/3546

comparable datasets, as well as by running latent class analyses to test whether a four-class model is the best fitting in datasets which capture similar aspects of social participation (e.g. meeting friends and relatives, membership in formal groups and voluntary work) but use different measures (Muthén & Muthén, 2015). Additional research could be used to examine whether the four-class model prevails if additional measures of social participation activities are included. For example, ELSA does not capture popular social activities such as Skype contact with friends and family (Jones et al., 2015b) or visits to pubs or cafes (which may not be captured by the existing question asking about 'eating out'). Once the groups are established, movement between social participation groups over time could be examined using latent transition analysis (Muthén & Muthén, 2015). This would enable the stability of social participation activity in older people over time to be examined, and could be tracked alongside mental and physical health trajectories using dual trajectory analysis to test for reciprocal changes in health.

Future cohort study research is needed to examine the roles of social participation identified in this exploratory study in more detail. Such research should consider using stratified random sampling methods (Field, 2013) to ensure all four social participation groups are represented adequately to enable comparisons between the four groups individually. This would preserve more information from the social participation measure, than using combined social participation groups such as was used in this study, and promote statistical power. Examining social participation using the full information available in the measure (rather than combining groups to form a binary variable for example) when testing the role of effect modifier and effect mediator may offer a more detailed understanding of the role of social participation in maintaining health in older people with musculoskeletal pain. Descriptive analyses reported in Chapter Six identified significant differences in health and wellbeing characteristics between infrequent and moderate socialisers. Therefore, it may be that if the referent group is infrequent socialisers, rather than infrequent and moderate socialisers combined, then the effect modifying effect of social participation may be stronger and shown to be statistically significant.

A purposely designed cohort of older people could include a validated measure of musculoskeletal pain, such as a question on the presence of pain accompanied by a body manikin for the location to be identified on (Van der Hoven et al., 2010). The empirical findings from the effect mediation analyses require validation of the concepts and relationships between them. A 'sense of purpose' was identified as explaining the observed influence of social participation in promoting both mental and physical health among older adults with musculoskeletal pain, and further qualitative and quantitative work is needed to develop and support this theory.

There is a need for further research to more closely unpick effect modification by social participation of the association between musculoskeletal pain and mental health, which appears to be multifactorial, complex and different for men and women (Takagi, et al., 2013;Asztalos, et al., 2010). As the benefits of social participation have also been suggested to differ between men and women (Kavanagh et al., 2007), it is possible that gender may be a moderator of effect modification of musculoskeletal pain–to-mental health association by social participation. Further research should examine for moderated-moderation to test whether gender is an effect modifier of the role of social participation as both an effect mediator and as an effect modifier of the association between musculoskeletal pain and health outcomes.

Applied clinical research is needed to examine the effectiveness of interventions promoting a sense of purpose (e.g. the use of self-observation, reflection and life review, psychoeducation and cognitive behavioural strategies) in reducing the risk of deteriorating mental and physical health in older people with musculoskeletal pain. Such techniques have been shown in a small pilot study to improve a sense of purpose in older people when provided weekly for one hour in community settings, for an 8-week period (Friedman, et al., 2015). The improvements in wellbeing associated with interventions promoting a sense of purpose have been shown to persist at 6 months (Dubé, et al., 2005). Such interventions could help older people with musculoskeletal pain to adapt and adjust their goals and expectations to maintain a sense of purpose, and accommodate limitations arising from their pain so as to mitigate the negative impact musculoskeletal pain has upon subsequent sense of purpose.

9.7 IMPLICATIONS OF THE STUDY FINDINGS FOR POLICY AND PRACTICE

The thesis findings have important implications for those commissioning and providing primary care services for older people. Musculoskeletal pain is not only a known antecedent of deteriorating health in older people, but also a target used to identify those with important rehabilitative and supportive healthcare needs (Breivik, et al., 2013). Consequently, learning more about how to mitigate the negative impact of musculoskeletal pain upon health in older people provides important insight at a time when public health policy and research priorities are strongly focussed on maintaining health in older people. The findings of this study make a useful contribution to the evidence base informing healthcare policies and guidelines. For example, the findings are pertinent to the NICE quality standard 'Older people: independence and mental wellbeing' (NICE, 2015) which provides guidance on the type of activities to offer older people to promote mental wellbeing. The findings of this study support the recommendation that older people should be supported in activities which promote a sense of purpose, as well as providing additional information by identifying a group of older people at increased risk of deterioration (those with musculoskeletal pain). Policy relating to working in later life should acknowledge the importance of maintaining a sense of purpose, whether arising from employment or other activities, as an important aspect of healthy aging. Supporting older people with musculoskeletal pain to continue to fulfil social roles which provide them with a sense of purpose is an important public health target.

Social participation predicts the maintenance of health, independent of musculoskeletal pain and baseline health status, suggesting interventions promoting social participation may benefit the health of all older people regardless of pain status. This also provides evidence that musculoskeletal pain should not be a reason to exclude older people from programmes as all older people have potential to significantly benefit in health terms. Social participation interventions, especially those targeting a sense of purpose, offer a possible long-term care prevention strategy at a community-level (NICE, 2015), which emphasises primary prevention rather than a 'high-risk approach' based upon identifying and targeting individuals (Ichida, et al., 2013). Such preventative health strategies have potential to maintain health rather than trying to restore health once it has deteriorated, and so can help reduce the burden on primary care services by reducing consultations and reducing the impact of existing health conditions such as musculoskeletal pain in older people. Examples of such interventions include supporting and up-skilling older people to fulfil personal projects (Culph et al., 2015;Dubé et al., 2005).

Furthermore, interventions based around social participation, a sense of purpose and physical activity can be effectively provided by third sector organisations (Friedman et al., 2015; Parks, 2014). At a time when commissioners are having to make difficult decisions regarding which services to provide, the role of third sector organisations is becoming increasingly important. There is also a potential opportunity for greater use of online resources targeting socially isolated older people, as even virtual social participation has been found to benefit mental health and reduce loneliness in older people (Cotton et al., 2013;Fokkema & Knipscheer, 2007). One way this could be used to help older people with musculoskeletal pain is through links to online socialising resources and sites with information about local social events. For example, Skype™ and Virtual Senior Centers can remove barriers to participation through the use of electronic connections (Szanton, et al., 2016; Findlay, 2003). A review of the empirical literature on the effectiveness of interventions by Findlay (2003) found that computer-based functions such as email may be one of most beneficial interventions to facilitate social participation and reduce social isolation in older populations. Online support websites could also promote social participation by offering opportunities for older people with musculoskeletal pain who may have mobility restrictions or difficulty leaving their neighbourhood to take-up roles and responsibilities online promoting a sense of purpose.

Social participation interventions have already been piloted in some areas across the world. For example, Ichida and colleagues (2013) reported a significant improvement in the self-rated health of older people who utilised community-centres which were opened as part of a drive to promote social participation in older people living in rural Japan. The activities carried out ranged from arts, singing, playing instruments, haiku composition etc. to unstructured 'free socializing'. Such a centre enables individuals to select activities which resonate most strongly with their likes and desires, and so is likely to enhance an individual's sense of purpose. Ichida et al., (2013) conclude that investing in community infrastructure to boost the social participation of communities is likely to promote healthy ageing. Similarly, Jones and colleagues (2015b) studied the impact of enabling a group of

32 volunteers, aged ≥50 years, to provide technical support to 144 older people (beneficiaries) aged ≥65 years. The researchers did not assess any perceived benefit of the volunteers, but the beneficiaries reported increased contact with family and friends and some improvements in mental health. Skype was particularly utilised, with 38.9% of the beneficiaries using it regularly at follow-up to communicate with friends and family.

9.8 WHAT DO THE FINDINGS OF THIS STUDY MEAN AND WHY DO THEY MATTER?

The importance of the main objective of the thesis has been discussed in section 9.2 above. This objective faced a number of challenges, and these shape any critical assessment and judgement about the meaning of my results. These are:-

1. ELSA was chosen as a source of secondary population data to address the thesis objective. Such cohort datasets have a number of advantages. ELSA is prospective and so cause-to-effect hypotheses can be constructed and analysed using ELSA data. It has multiple time points in follow-up and so detailed causal pathways (such as effect modification) can be investigated. However these analyses will have limitations to their meaning, chief among which is that the measurements of complex concepts like social participation will be inevitably crude and so associations may be missed or may too easily overlap or be confounded by other similar linked concepts. I therefore spent a substantial part of the methodological component of this thesis developing a classification of the information about social participation in ELSA.

The first result was a confirmation in ELSA data of a finding from studies by others, namely that social participation measured as a broad concept in populations is a predictor of future physical and mental health. This has a descriptive rather than a clearly causal interpretation – although it was robust to adjustment for several confounding factors. However this finding is important in itself, i.e. people who (for whatever complex reasons) currently report themselves to be active social participators are less likely to suffer mental and physical ill-health later on. The added meaning from this ELSA analysis is that the finding was independent of concurrent baseline musculoskeletal pain. The finding cannot alone generate any direct simplistic conclusions about new interventions or targets for treatment, but it does provide concrete empirical epidemiological evidence to support the idea that positive social engagement is a marker for future health that is not abolished by having pain. This finding could and should feed into necessary debates about social and public health policies to reduce the impact of musculoskeletal pain, and help to drive more research into social engagement as a potential component of such policies.

2. The second objective was to investigate more precisely articulated causal pathways for social participation (as measured in ELSA) as a potential influence on the relationship between musculoskeletal pain and future physical and mental health, whether as a modifier of the influence of other variables on these outcomes in people with pain or as a direct cause or partial cause of these outcomes. These

were novel objectives, but ELSA provided an appropriately robust framework to carry them out because of the multiple follow-up points. The overall findings of these analyses, after adjustment for other baseline variables and bearing in mind the possible dilution of real effects because of missing data, were mostly negative, with the exception that social participation did explain some of the impact of pain on future mental health. This means that active social participation as measured in ELSA, although it is clearly and importantly linked at group level to better health outcomes in general, does not alone present a clear or precise target for changing the impact of chronic musculoskeletal pain on future health according to the pathway analyses presented in this thesis.

3. Taken together the findings from 1 and 2 above confirm both the importance of social participation (as measured in ELSA) but also its limitations in being a very broad concept and too blunt a measurement for investigating causality and potential targets for intervention. Much recent research (Joshanloo, 2018; Ryff, 2017) suggests that the broad concept of social participation both contains and obscures a much more complex and nuanced set of factors, which may present more precise targets for intervention that could impact on the experience of pain in the general population. As part of the objective of this thesis to examine the role of social participation as an effect mediator (of mental and physical health), I therefore explored the association between three distinctive factors available in the ELSA dataset and hypothesised to be accessed through social participation (a

sense of purpose, social support and physical activity) and health outcomes in older people with chronic musculoskeletal pain. Two factors (sense of purpose and physical activity) emerged as having a direct link with both physical and mental health, to which the general measure of social participation did not add. This evidence adds to the evidence-base for physical activity being an important component of maintaining health in older people with chronic musculoskeletal pain (Holden et al., 2015; Kuh et al., 2014; Hamer et al., 2009). The evidence of a role of a sense of purpose chimes with other work examining factors associated with maintaining and improving health (Yeung et al., 2018; Ryff, 2017; Elliot, 2016; Culph et al., 2015; Windsor et al., 2015). The increasing body of evidence indicates the importance of psychological factors in driving the maintenance of health in older people with chronic musculoskeletal pain, and older people more generally.

Investigating both of these factors in future practical intervention trials in older people with musculoskeletal pain seems justified on the basis of the results of this thesis that have demonstrated their direct independent influence on future health. However the ELSA social participation measure did not add to this influence, highlighting again that the broad concept of participation at older ages would not alone provide a target for interventions aimed to overcome the impact of pain. However the evidence from this thesis does justify continuing to explore social participation as a general driver of positive health into old age and as a general marker of an important component of public health and healthy ageing.

One final reflection concerns the finding that social participation was associated with health outcomes in people with chronic musculoskeletal pain in the crude analysis, but this effect disappeared after adjustment, notably for baseline levels of physical and mental health. The finding highlights that, even in a longitudinal cohort like ELSA, health status and behaviours like social participation have long-term trajectories with complex interactions and causal patterns that defy a simple epidemiological separation into baseline and follow-up for cause-and-effect analysis. The reality is that, already by the time of the baseline (i.e. wave 2 in this analysis), most ELSA respondents with pain will have had a long past history of pain and participation. Measuring the effect of social participation at baseline on future outcomes therefore becomes swamped by the larger influence of concurrent baseline health status. This is likely to matter for three reasons –

i) longer-term influences of social participation might need to be addressed earlier in life for causal links to be established;

ii) adjusting for levels of health or chronic illness at baseline may represent over-adjustment in any study of the effect of social participation on future health;

iii) it provides further justification for investigating more precise components of social participation (as described in paragraph 3 above) in ELSA to establish short-term targets for intervention, since a broad construct like social participation (taken as an isolated epidemiological measurement away from multiple other domains of social and psychological and physical health) may not provide a sufficiently robust or precise basis for causal studies or intervention targets.

In summary active social participation is linked with future physical and mental health in older people and this analysis of ELSA data justifies continuing to explore ways to promote social participation as a component of active ageing policies. The thesis results however suggest that this is likely to be too simple a model for the specific prevention of disabling musculoskeletal pain at older ages. More specific targets such as 'sense of purpose' and 'physical activity', related to social participation, could provide targets later in life for promoting and maintaining health in people with long-term musculoskeletal pain.

9.9 CHAPTER SUMMARY

This thesis makes an original contribution to the literature, providing evidence to suggest social participation explains why some older people with musculoskeletal pain maintain their health. However, the role of social participation as an effect mediator and effect modifier largely becomes insignificant once other putative confounders (age, gender, economic adversity, existing mental and physical health and chronic limiting illness) are adjusted for. Older people with musculoskeletal pain who frequently socially participate are as likely to maintain their mental health as their counterparts without musculoskeletal pain, and have better mental health than those with musculoskeletal pain who are infrequent socialisers. A sense of purpose and physical activity are facilitated by frequent social participation, and may better represent the underlying causal pathways between musculoskeletal pain and mental and physical health. The findings also support existing evidence that social participation is a strong, independent predictor of mental and physical health in older people with and without musculoskeletal pain.

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APPENDIX 1: DIRECTED ACYCLIC GRAPHS

Directed Acyclic Graph (DAG) theory provides a useful visual aid for clarifying the underlying causal relationships to be tested in a study and were utilised throughout this thesis as a method of developing and portraying analytical models to be tested by quantitative methods. A brief overview of DAGs is provided below. For a more detailed theoretical discussion of DAG theory the reader is directed to Pearl's comprehensive text (2000).

DAGs provide a visual representation of the a priori assumptions made about the relationships between and among variables in causal pathways (Pearl, 2000). *Directed edges* (arrows) link *nodes* (variables) to create *paths* (causal links between two variables). Each node must represent a distinctive variable even if one factor is measured at multiple time points, e.g. if variable X is measured at *k* time points it must be represented by *k* separate nodes in the corresponding DAG. A directed path is an unbroken sequence of distinct nodes connected by arrows (e.g. the path from X to Y (X→Z→Y), an undirected, or biasing path is a sequence of nodes in which one or more node in the path has two incoming arrows (X→Z←Y). If a biasing path begins with an arrow coming into X it is known as a back-door path. Edges must not lack direction or be bidirectional, as to do so would violate the 'directed' characteristic of a DAG (Pearl, 2000). Equally no node should have an arrow which points to itself, as this would contravene the acyclic nature of the DAG which specifies that no directed path from any node to itself is allowed (Pearl, 2000). These rules enforce the understanding that causes must precede their effects (Sauer & VanderWeele, 2013).

When developing a causal DAG the researcher must specify their a priori understanding of all the relationships and dependencies among variables. Construction of DAGs should not be limited to those variables for which measured data is available, but rather constructed independently according to background knowledge of factors constituting the causal network encapsulating the association of interest (Sauer & VanderWeele, 2013). Most importantly any common cause of two or more variables featuring on the DAG must be included. Variables that only causally influence one other variable are called exogenous variables, and may be included or omitted from the DAG. Absence of a path between two nodes is interpreted as a statement of an absence of causal path between the two respective nodes.

When examining the effect of X on Y an open back-door path (i.e. an indirect path between X and Y which includes a variable which itself effects X) which contains a confounding variable can produce a spurious association between the two variables even if X has no effect on Y. To calculate an unbiased estimate for a specific path between two variables, paths other than that of interest must be closed (Shpitser & VanderWeele, 2011).

Closing a path entails controlling for the relevant variables using statistical techniques, i.e. regression adjustment, stratification, or restriction. However whilst controlling for confounding variables is necessary to prevent distortion of the association between X and Y, such adjustment must be theoretically justified, as unnecessary adjustments may actually introduce bias. If a path contains a collider, a third variable that is a common outcome of two variables on a path between X and Y, then it naturally blocks a potentially confounding path (Textor, 2015). In the case of a collider variable it is the act of controlling which instead may introduce bias to estimated association of X on Y. Additionally adjusting for an effect of X on Y should never be performed as this constitutes a source of over-adjustment and will attenuate the effect of interest towards the null (Pearl, 2000).

Using DAG theory, bias in estimates of X→Y is addressed by 'closing' any alternate paths by which X can influence Y, other than the path of interest. The minimal sufficient covariate adjustment set is the most parsimonious group of covariates which must be adjusted for to isolate the effect of X and Y. Minimal adjustments are important because excessive adjustment for variables may decrease statistical power. A path is closed if the following criteria (Textor, 2015) are met:

i) The path contains a chain X→Z→Y, or a fork X←Z→Y, where Z is in the minimal sufficient covariate adjustment set

ii) The path contains a collider X→C←Y such that C is not in the minimal sufficient covariate adjustment set, which additionally does not contain any successor of C found in the DAG

APPENDIX 2: NUMBER OF CITATIONS YIELDED BY DATABASE SEARCHED

Database	Search platform	Date searched	SP No. retrieved	Pain No. retrieved	Pain and SP combined No. items retrieved	No. unique items: No. duplicated in search	No. duplicated within previous searches	No. individual items retrieved by search	Total no. items retrieved
Medline	NHS Evidence	13/01/2014	26279	369055	979	975: 4	-	971	971
AMED	NHS Evidence	13/01/2014	2518	19983	206	205: 1	138	67	1038
BNI	NHS Evidence	13/01/2014	1570	4052	37	37: 0	16	19	1057
CINAHL	NHS Evidence	13/01/2014	15465	132335	648	645: 3	351	294	1351
EMBASE	NHS Evidence	15/01/2014	64634	553782	2494	2420: 74	978	1444	2795
PsycINFO	NHS Evidence	16/01/2014	80095	27834	644	641 : 3	208	433	3228
Ageline	EBSCO	16/01/2014	10853	3271	372	372: 0	10	362	3590
Cochrane Database	Wiley Online Library	18/01/2014	971	39080	80	77 : 3	4	73	3663
SCI-EXPANDED, SSCI, CPCI-S, CPCI-SSH	Web of Science	20/01/2014	71794	315,598	1672	1665:7	3	1662	5325
OpenGrey	OpenGrey	23/01/2014	84 (43 English)	27 (13 English)	0	0	0	0	0
EThOS	EThOS	23/01/2014	240	726	2	2:0	0	2	5325
ProQuest	ProQuest	24/01/2014	107821	18957	262	260:2	1	259	5584
SP= social participation, No. = Number of									

APPENDIX 3: SUMMARY OF FOCUS GROUP STUDY

A focus group study of a group of older people residing in a sheltered housing village who reported both musculoskeletal pain and maintaining good health was used to examine whether their experiences were captured by the theoretical model developed from the literature, and to identify any revisions necessary to improve the model. Focus groups are 'a way of collecting qualitative data by engaging a small number of people in an informal group discussion focussed on a particular topic or set of issues' (Wilkinson, 2003). The interaction process during a focus group stimulates memories, discussion, debate and disclosure in a way that is less likely in a one-to-one interview (Wilkinson, 2003). Contrast and/or agreement of experiences and opinions arising in the discussion can be probed and explored as participants build upon each other's contributions, which can produce a broader as well as more in-depth understanding of a phenomena (Milward, 2012). Consequently, a focus group study[18] was chosen as an appropriate method to explore how social participation determines mental and physical health in older people with musculoskeletal pain. The focus group study was approved by the Keele University Ethical Review Panel (approval April 9, 2015, project reference ERP329).

Methods:

A sheltered retirement village in the West Midlands was chosen as the setting for recruiting a purposive sample of community dwelling older people. Focus group participants were recruited by questionnaires distributed to residents of a retirement

[18] The focus group study was presented as a poster presentation at the School for Primary Care Research Annual Showcase (Oxford), 2017, and was awarded a prize following peer-review.

village. Participant eligibility criteria included: troublesome pain, reporting frequent social participation and having good self-rated health. Six women took part in the focus group discussion, which lasted 1 ¼ hours and was audio-recorded. Written consent was obtained from all participants, who were allocated a pseudonym to present data and to ensure anonymity.

Thematic analysis was selected as an appropriate method to identify distinctive ways in which social activities contribute towards good health in older people. Thematic analysis offers the researcher a systematic, inductive approach to coding and interpreting the data (Braun & Clarke, 2006). The themes were developed both deductively from existing literature informing the quantitative analyses (i.e. social support and physical activity), and inductively from the accounts (experiences and views) of the participants. Themes developed into an exploratory model of the relationship between pain and self-reported good health.

Summary of participant sociodemographic, pain and health characteristics for focus group participants

	Connie	Rhoda	Beatrice	Nora	Jessie	Marie
Age (years)	68	72	80	82	85	76
Time resident at village (years)	7	5	17	2	17	1
Social participation profile*	FL	FH	FL	FH	FH	FL
Self-rated health	Very good	Good	Very good	Excellent	Good	Good
Often troubled by pain?	A little	Moderately	Quite a bit	Moderately	A little	A little
Pain severity	Moderate	Moderate	Severe	Severe	Moderate	Mild
Pain interference in past 4 weeks	-	Moderate	Moderate	Not at all	A little	Not at all
SF-12 score: Mental health	-	65.3	52.8	60.5	62.6	58.5
SF-12 score: Physical health	-	33.1	44.0	47.5	36.4	32.3

**See Chapter 6,, Table 6.5, for a detailed description of the social participation profiles. FL= Frequent social participation, low community engagement, FH= Frequent social participation, high community engagement*

Findings:

Participants were all female and ages ranged from 68 to 85 years. No men expressed a wish to participate in the study, and are historically more difficult to recruit onto such studies (Field, Walker, & Orrell, 2002). Participants' descriptions of the impact of pain was primarily through reduced daily function, pain severity was not highlighted as an important determinant during the discussions. Existing morbidity (e.g. heart problems, stroke and previous physical injuries) and environmental factors (e.g. availability of suitable seating and accessibility) influenced the both pain and social participation. Personal characteristics (e.g. preferred social activities and having a strong mental attitude) also influenced an individual's choice of social participation and ability to maintain it. Overall, frequent social participation contributed towards subsequent good health through three broad pathways:

i) providing a sense of purpose;

ii) providing access to social support;

iii) and maintaining physical activity

Examples of data extracts supporting the three broad pathways identified by which social participation influenced health:

<u>Sense of Purpose</u>

- *'I'm actually the most able <of my old friendship group> since I've been in here, I think it's kept me going... because they do a lot of sitting on their own and your mind goes down and down'* (Jessie, 85)
- *'A lot of it was the carers, to push up and go, keep going'* (Connie, 68)

<u>Social Support</u>

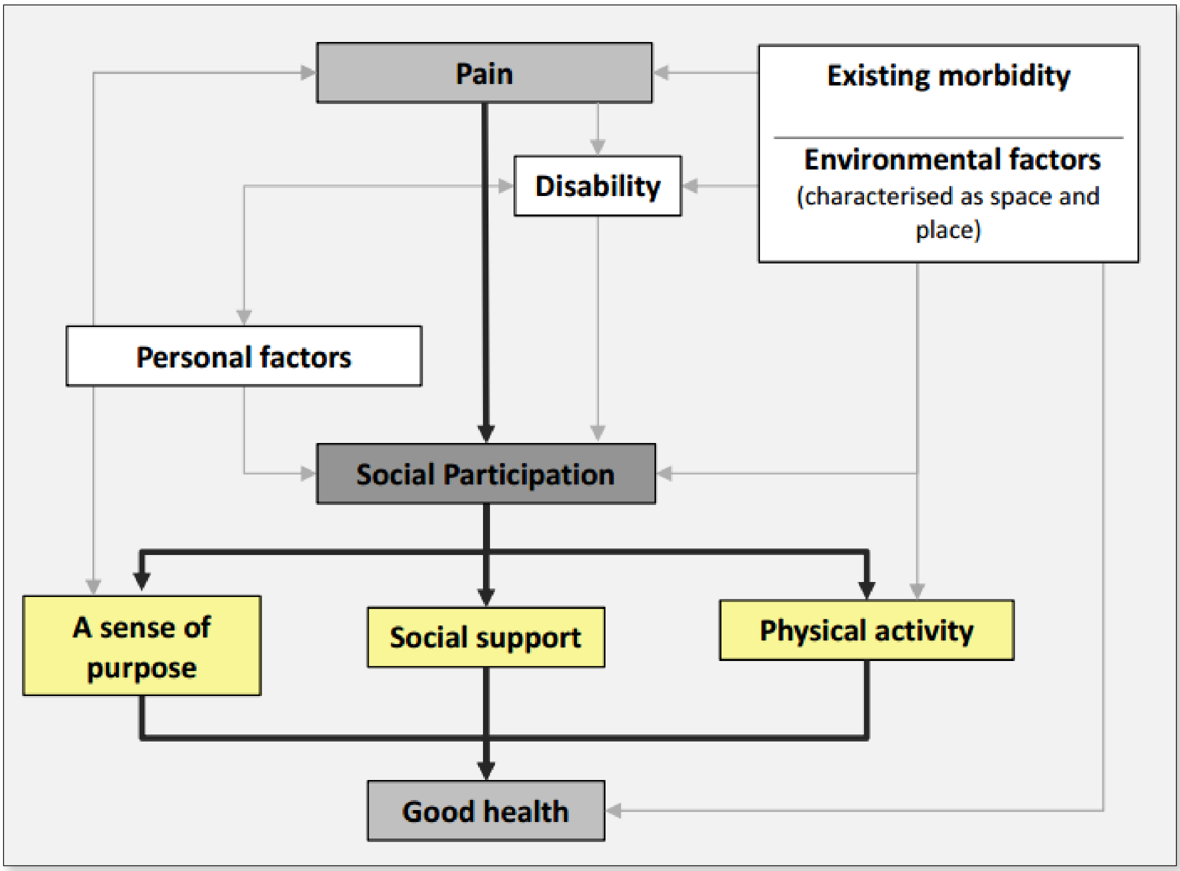
- *'It sort of helps if you're talking to other people, who've got something similar*
- *to what you've got, and you can go off their experience as well'* (Rhoda, 72)
- *'I lost my twin sister on the Wednesday, and my husband dies on the Sunday,*
- *but I was in here, and I'd got this environment round me'* (Beatrice, 85)
- *'I'm alright here, I mean if I'd been at home I'd have been on my own all the time. I've only got one son and I don't see him very often'* (Marie, 76)

<u>Physical Activity</u>

- *'It gives you exercise 'cos you're walking up and down and using your arms for bowling like... and bending your knees'* (Nora, 82)

- *'When I was at home…I had to give up gardening because it was too much … but when I got here I thought I'd have a go.. you know I couldn't have done that on my own…(here) I could share the work'* (Jessie, 85)

Model showing the role of social participation in maintaining good health in older people with pain



The focus group study contributed to the validation of the theoretical model of the role of social participation in maintaining health in older people with musculoskeletal pain. The narratives of the participants provided narratives of the lived experiences of older people with musculoskeletal pain who maintain good health. Particularly of note was the complex relationship between the factors included in the theoretical model, with changes in any of the constructs able to destabilise an individual's health status.

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APPENDIX 4: Testing for effect mediation using the product of the coefficients approach

The product of coefficients approach assesses the mediating effect of a third variable by considering the following two regression equations (MacKinnon, et al., 2014):

$$Y = i_1 + c'X + bM + e_1 \qquad (Eq.1)$$[19]

$$M = i_2 + aX + e_2 \qquad (Eq.2)$$

Coefficient a relates X to M, coefficient b relates M to Y adjusting for X, the product ab is the mediated effect of the indirect path. The c' coefficient relates X to Y adjusting for M. The theoretical underpinning of the product of the coefficients method is that the mediation effect depends on the extent to which X affects M, and the extent to which M affects Y. The indirect path $X \rightarrow M \rightarrow Y$ is the mediation process, and c' the remaining direct effect of X on Y, which is not mediated by M (MacKinnon et al., 2014).

The significance of the intervening variable effect is generally tested by dividing the estimate of the intervening variable effect, ab, by its standard error and comparing this value to a standard normal distribution (MacKinnon, et al., 2002). However, simulation studies have identified that using coefficient based methods to test the significance of the intervening variable effect can lack power because the distribution of the product of regression coefficients a and b are often asymmetric, with high kurtosis rather than being

[19] Y is the outcome variable, X the exposure variable, M the putative mediating variable, i the intercept and e unexplained variability (MacKinnon, et al., 2014). a is the beta coefficient of X as a predictor of M, b the beta coefficient of M as a predictor of Y, and c' the coefficient for the direct effect of X on Y.

normally distributed (MacKinnon, et al., 1998). In this study, to address this limitation bootstrap confidence limits (CI) were used which enables asymmetric confidence intervals to be generated (Muthén & Muthén, 2015) to accommodate any non-normal distribution of the mediating variable effect (MacKinnon, et al., 2002). The test of significance for asymmetric confidence intervals is given in Equation 3:

$$ab \pm CI \sqrt{a^2\sigma_b^2 + b^2\sigma_a^2} \qquad (Eq.3)$$

ASSUMPTIONS OF THE PRODUCT OF THE COEFFICIENT APPROACH

In addition to assuming pain, social participation and mental/physical health measurements follow the necessary temporal sequence, the product of coefficients approach assumes a correctly specified causal direction (i.e. no reciprocal causation or reverse causality), no misspecification due to omitted variables (e.g. unmeasured confounding) and minimal measurement error (MacKinnon et al., 2014). Any measurement error is assumed to be uncorrelated (Pearl, 2014). Another key assumption of the product of the coefficients approach is sequential or conditional ignorability where, after controlling for observed covariates, the treatment assignment is assumed to be statistically independent of potential outcomes and potential mediators (Imai et al., 2011). In this study this amounts to assuming that conditional on whether or not a case has pain, and on other observable controlled variables, the level of social participation is independent of health outcome. Finally, it is assumed that any mediating effect is of a linear nature (MacKinnon et al., 2002). More complex models are needed to accommodate none linear effect mediation (e.g. moderated mediation).

BINARY MEDIATORS AND OUTCOMES

If either M or Y is a binary variable, standard methods of estimating the indirect and direct effects should not be used because the dependent variable (i.e. M or Y respectively) has a non-linear distribution and so generated coefficients are a function of a fixed error term (MacKinnon, et al., 2014). When estimating the indirect effect and extent of any mediating effect the necessary regression coefficients are therefore on different scales. This problem is addressed by standardising the estimates for paths a and b (Stride, et al., 2015; Herr, 2006) before estimating the indirect effect:

$$\text{adj. a} = \frac{\text{sd(X)a}}{\sqrt{(a^2Var(X) + \frac{\pi^2}{3}}} \qquad (Eq.7.5)$$

$$\text{adj. b} = \frac{\text{sd(M)b}}{\sqrt{(c'^2Var(X) + b^2Var(M) + 2bc'Cov(X,M) + \frac{\pi^2}{3}}} \qquad (Eq.7.6)$$

In Equations 7.5 and 7.6 $\frac{\pi^2}{3}$ is the variance of the standard logistic distribution. When the dependent variable in a mediation path component is binary the regression equations must be modified to the relevant logit model[20] (Herr, 2006). Equation 7.7 represents a binary outcome Y, and Equation 7.8 a binary mediator M.

$$Logit\ (Y'') = i_1 + c'X + bM + e_1 \qquad (Eq.7.7)$$

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[20] M and M′ represent the same mediating variable, however as the coefficients are measured on different scales a dash is added to indicate this. Equally Y′′ represents the binary outcome of a c′ path, and Y′ the binary outcome of a total effect path from X.

$$Logit\ (M') = i_2 + aX + e_2 \qquad (Eq.7.8)$$

Equation 7.9 represents the total effect of X on Y when Y is binary.

$$Logit\ (Y'') = i_1 + c'X + bM + e_1 \qquad (Eq.7.9)$$

However, if both the mediator and the outcome are binary (i.e. all dependent variables in the path analysis, then the standardisation of estimates for paths a and b before calculating the indirect effect is not necessary (Herr, 2006).

MacKinnon, D., Lockwood, C., Hoffman, J. 1998. *A new method to test for mediation.* Paper presented at the annual meeting of the Society for Prevention Research; Park City, Utar.

APPENDIX 5: TESTING FOR EFFECT MODIFICATION

There is some ambiguity over how is best to statistically test for 'effect modification' (Shahar & Shahar, 2010). In epidemiology effect modification is usually tested for using multivariable regression models (Marsh, et al., 2013), although the exact approach taken to testing for effect modification may take one of three common strategies:

i) **Comparison of observed and expected joint effects** - testing whether the observed joint effects of the exposure (X) and third variable (Z) upon an outcome (Y) differs from that expected by using the independent effects of X and Z to calculate a priori the expected joint effect which is then compared to the observed effect

ii) **Assessment for interaction** - testing for a statistical interaction by adding a new variable multiplicative term, XZ, into a multivariable regression model predicting Y

iii) **Assessment of homogeneity of effect** - testing whether the observed association between X and Y differs across sample subgroups stratified according to levels of Z (stratification)

TESTING FOR STATISTICAL INTERACTION

Using interaction terms enables the coefficients for two predictors (e.g. pain and social participation) change from partial effects to conditional effects once the interaction term between pain and social participation is added into the regression model, so the full effect of pain is spread between the coefficients of pain and the interaction term when $Y \neq 0$.

Equation 1 shows the regression equation including an interaction term for a binary outcome:

$$Logit\ (Y) = i_1 + b_1X + b_2Z + b_3XZ + e_1 \qquad (Eq.1)$$

When binary 0/1 coding is used, the parameter estimate and standard error of pain are interpretable as the value for pain conditional on social participation being coded '0' (i.e. the unique effect attributable to pain when the effect of social participation is absent) in the interaction model, whereas in the corresponding model with the interaction term equals zero the coefficient for pain quantifies the effect of reporting pain upon mental/physical health when social participation is held constant (Hayes, 2013). In the unconditional model the effect of social participation is assumed to be consistent across all values of pain, therefore the coefficient of pain is not conditional upon the value of social participation.

In a model without an interaction term the coefficients of pain and social participation represent the unique effect of one variable when the other is set at zero. However, upon addition of an interaction term the unique effect of pain or social participation respectively is not limited to the coefficient of that individual variable, but also depends on the value of the other as both contribute to the interaction term (Hayes, 2013). This makes interpretation of complex models including covariates more challenging because in single group analyses the coefficients for covariates represent the effect observed for that variable across the whole sample (Spicer, 2005). If a statistical interaction is found stratification can be used to more closely examine the effect of the exposure on the outcome across different levels of the effect modifier in a more intuitively interpretable way (van Ness & Allore, 2004). Stratified analyses can isolate the effect of the exposure on the outcome for a pre-specified value of the effect modifier, and the exposure coefficient represents the unique effect of the exposure in that strata (Hayes, 2013).

BINARY EFFECT MODIFIERS

Hayes (2013) explains that for a binary effect modifier the conditional effect of an exposure on an outcome is zero can be interpreted using β_1, where β_1 is the beta coefficient for the exposure. However, the analysis should be re-run with the binary effect modifier reverse coded to obtain the conditional effect of the exposure on the outcome for the alternate effect modifier status. For example, if the exposure measures pain (1) or no pain (0), and the outcome is whether an individual has mental health, and the effect modifier is defined as frequent social participation (1) or infrequent social participation (0) then the conditional effect of pain on mental health would give the effect of pain on mental health in those with <u>infrequent</u> social participation. If this differs statistically from zero then there is an effect of pain on mental health in infrequent social participators, but the social participation variable would need to be reverse coded to find the effect of pain in high socialisers. The conditional effect of pain on mental health still represents the conditional effect of pain on mental health when social participation is coded zero, however now a score of zero represents frequent social participation.

MULTIGROUP ANALYSIS

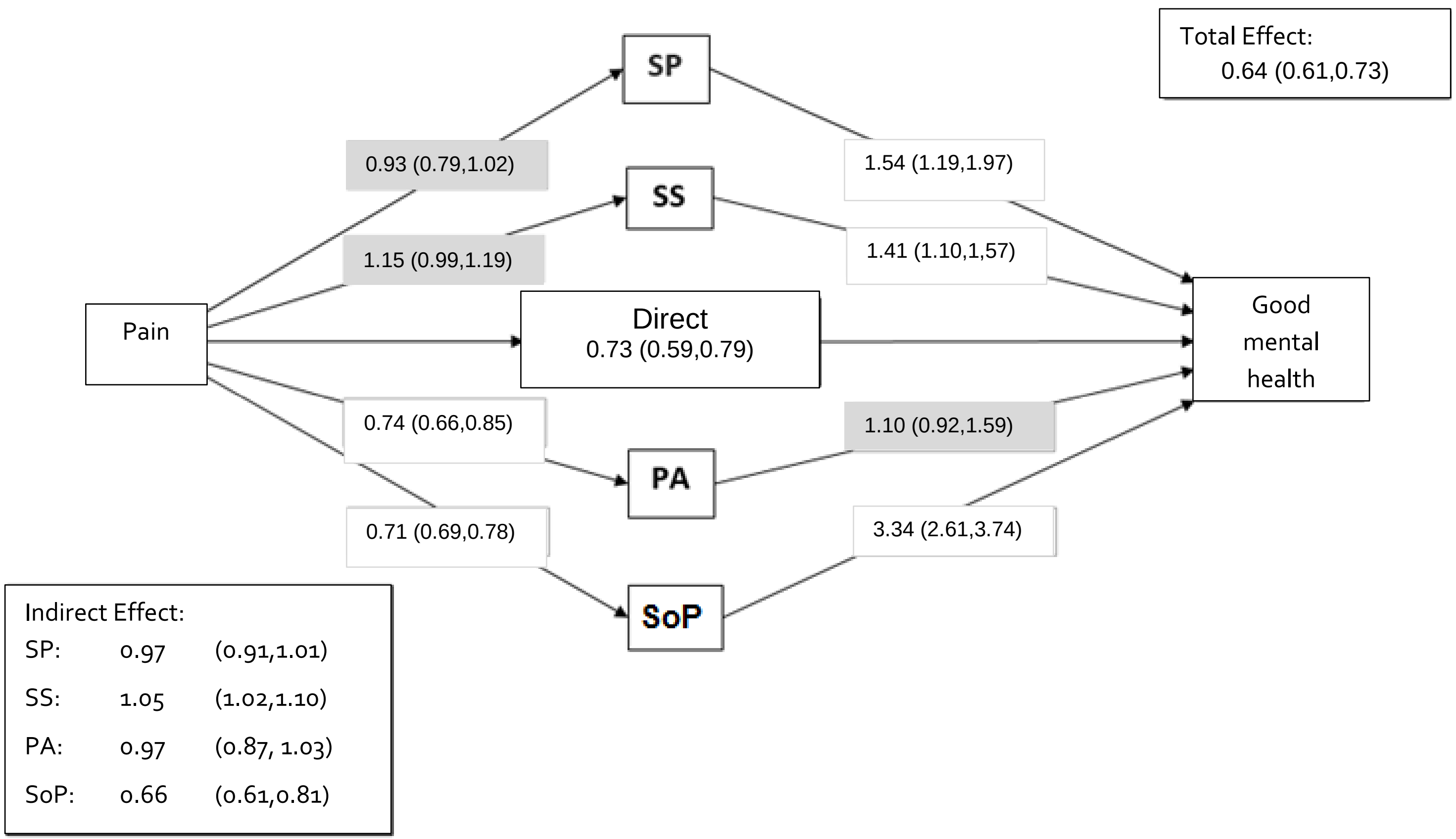
When theoretically justifiable cut-points are available for the moderator variable then multigroup analysis is recommended for exploring effect moderation (Sarstedt et al., 2011). Estimating the parameters for all subgroups simultaneously rather than individually has the following advantages:

- The method provides an omnibus test for significance of any between group differences (Sarstedt, et al., 2011);
- Unlike performing a series of analyses with a fixed alpha (e.g. set at 0.05, or Bonferroni adjusted 0.05/n) for each pair-wise comparison a single test is performed, reducing the overall likelihood of a type 1 error (Sarstedt, et al., 2011);
- The fit of the theoretical model to each subgroup can be examined by consulting the Chi-square contribution of each subgroup to the overall chi-square statistic (Muthén & Muthén, 2015), whereas the fit statistics of single group models with an interaction term refer to the sample overall.

If the moderator variable is continuous rather than categorical then multigroup analysis is not recommended. Cut-off values selected when creating groups from a continuous effect moderator are often arbitrary, based upon distributional parameters (e.g. a median split or quartiles), thus generating groups which do not naturally exist. In this instance multigroup analysis may have lower statistical power, and confounding by differences in group variances may distort true moderator effects. Conversely, using interaction terms maintains original scores on a moderator variable and avoids loss of information resulting from transformation of a continuous variable to a categorical one (Bagozzi et al., 1992).

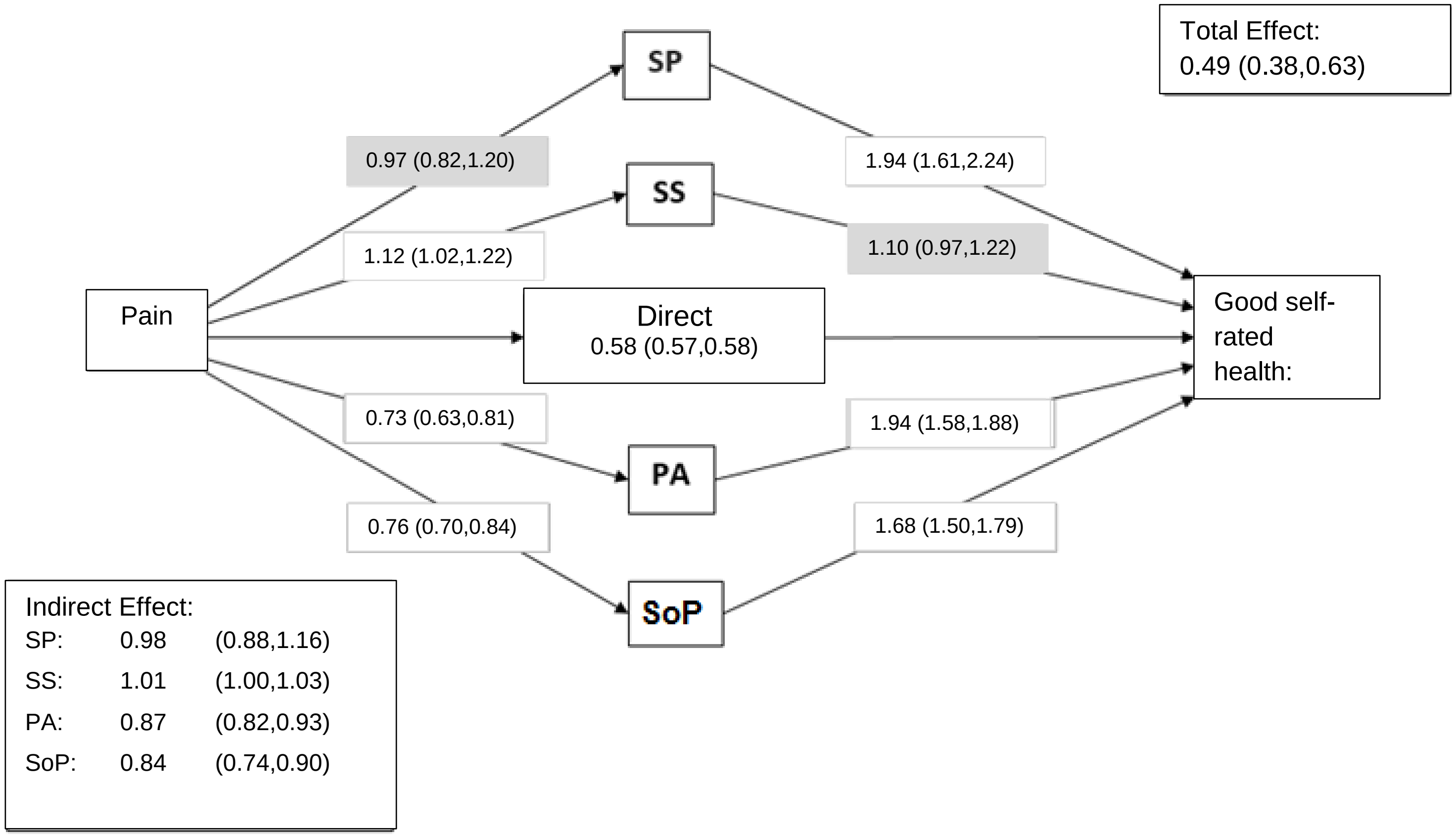
Bagozzi, R., Baumgartner, H., Yi, Y. 1992. State versus Action Orientation and the Theory of Reasoned Action: An Application to Coupon Usage. Journal of Consumer Research;18:505-518.

APPENDIX 6: MENTAL HEALTH MULTIPLE EFFECT MEDIATOR MISSING DATA ANALYSIS



Path diagram of the fully adjusted multiple mediator FIML model using cases with missing data, including social participation (SP), social support (SS), physical activity (PA) and a sense of purpose (SoP)

APPENDIX 7: PHYSICAL HEALTH MULTIPLE EFFECT MEDIATOR MISSING DATA ANALYSIS



Path diagram of the fully adjusted multiple mediator FIML model using cases with missing data, including social participation (SP), social support (SS), physical activity (PA) and a sense of purpose (SoP)

APPENDIX 8: RESEARCH DISSEMINATION AND PUBLICATIONS

Publications

Saunders, B., Sim, J., Kingstone, T., **Baker, S.,** Waterfield, J., Bartlam, B., Burroughs, H., Jinks, C. (2017) Saturation in qualitative research: what, where, why, when, and how? Quality & Quantity.15:12. doi.org/10.1007/s11135-017-0574-8

Baker, S., McBeth, J., Chew-Graham, CA., Wilkie, R. (2017) Musculoskeletal pain and co-morbid insomnia in adults; a population study of the prevalence and impact on restricted social participation. BMC Family Practice;18:17. doi:10.1186/s12875-017-0593-5.

Oral presentations

Baker, S (2016) Maintaining Mental Health in Older People with Musculoskeletal Pain: A Longitudinal Study. NIHR School for Primary Care Research Annual Trainee Event 2016. Oxford, UK.

Baker, S (2016) Exploring the role of Social Participation in Older People with musculoskeletal pain. Primary Care and Health Sciences Postgraduate symposium 2016. Keele University, UK. (Oral presentation prize awarded)

Baker, S; McBeth, J; Wilkie, R; Chew-Graham, CA (2016) Exploring the role of Social Participation in Older People with musculoskeletal pain: A focus group study. Ageing 2016. London, UK.

Baker, S (2015) A mixed-methods approach to determining the role of social participation in maintaining mental and physical health in older people with musculoskeletal pain. Gerontology Research Exchange Programme June 2015. Keele University, UK.

Baker, S (2015) The role of social participation in determining mental and physical health in older people with musculoskeletal pain. Primary Care and Health Sciences Postgraduate symposium 2015. Keele University, UK.

Baker, S (2014) The role of social participation in older adults with musculoskeletal pain. NIHR School for Primary Care Research Annual Trainee Event 2014. Oxford, UK.

Baker, S (2014) PhD plan: The role of social participation in maintaining physical and mental health in older adults with persistent musculoskeletal pain. Primary Care and

Health Sciences Postgraduate symposium 2014. Keele University, UK. (Oral presentation prize awarded)

Posters

Baker, S; Chew-Graham, CA; McBeth, J; Wilkie, R; (2016) Using Latent Class Analysis To Identify Clinically Meaningful Social Participation Profiles In The Older Population. NIHR School for Primary Care Research Showcase 2016. London, UK.

Baker, S; Wilkie, R; Jordan, KP; Chew-Graham, CA; McBeth, J; (2016) Maintaining Mental Health In Older People With Musculoskeletal Pain: A Longitudinal Study. European League Against Rheumatism (EULAR) Annual Conference 2016. London, UK.