The role of health literacy in osteoporosis prevention

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Publications co-authored during candidature


Conference presentations arising from this work

International conference presentations

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Hosking SM, Pasco JA, Beauchamp A, Williams LJ, Buchbinder R, Brennan-Olsen SL. (Poster)

WCO-IOF-ESCEO World Congress on Osteoporosis, Osteoarthritis and Musculoskeletal Diseases, Florence, March 2017: Public health - Health literacy, role modelling and prevention. (International)

Non-sponsored symposium: Parental influences on offspring bone: Multidisciplinary evidence.

Hosking SM (Oral)

WCO-IOF-ESCEO World Congress on Osteoporosis, Osteoarthritis and Musculoskeletal Diseases, Florence, March 2017: Associations between health literacy and uptake of osteoporosis prevention lifestyle recommendations in Australian women. (International)

Hosking SM, Buchbinder R, Pasco JA, Williams LJ, Brennan-Olsen SL.
International Osteoporosis Foundation Asia-Pacific Regional Conference, Singapore, November 2016: Health literacy and uptake of dietary calcium recommendations in women. (International)

**Hosking SM, Buchbinder R, Pasco JA, Hyde NK, Williams LJ, Brennan-Olsen SL.**
(Oral)

American Society for Bone and Mineral Research Annual Meeting, Atlanta, September 2016: Health literacy and the agreement between osteoporosis defined by self-report versus bone mineral density results in older women. (International)

**Hosking SM, Buchbinder R, Brennan-Olsen SL, Hyde NK, Williams LW, Pasco JA.**
(Poster)

WCO-IOF-ESCEO World Congress on Osteoporosis, Osteoarthritis and Musculoskeletal Diseases, Malaga, March 2016: Associations between maternal health literacy and bone mineral density of offspring. (International)

**Hosking SM, Buchbinder R, Brennan-Olsen SL, Hyde NK, Williams LW, Pasco JA.**
(Poster)
Other conference presentations

Australian and New Zealand Bone and Mineral Society Annual Scientific Meeting, Gold Coast, August 2016: Health literacy and agreement between osteoporosis defined by self-report versus BMD results in older women.

Hosking SM, Buchbinder R, Brennan-Olsen SL, Hyde NK, Williams LW, Pasco JA. (Poster)

Australian and New Zealand Bone and Mineral Society Annual Scientific Meeting, Hobart, November 2015: Maternal health literacy and child bone health.

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Hosking SM, Dobbins AG, Pasco JA, Brennan, SL. (Poster)
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Hosking SM, Dobbins AG, Pasco JA, Brennan, SL. (Poster)
Preface

I have contributed to aspects of data collection for both the Geelong Osteoporosis Study (GOS) and the Vitamin D in Pregnancy (VIP) study, which form the basis of this work. I was solely responsible for the collection of Health Literacy Questionnaire (HLQ) data for women participating in the GOS, including developing the electronic database and online survey tool and entering all paper-based HLQ data. Throughout the 11 year follow-up of the VIP study, fellow PhD student Natalie Hyde and I conducted all appointments which included the collection of clinical and questionnaire data from both mothers and children. I performed all data analyses presented throughout this thesis under the supervision of co-authors listed within the manuscripts.
Abstract

Background

Osteoporosis and associated fragility fractures are increasing in prevalence and they are costly both in terms of financial costs to the healthcare system and personal costs associated with reduced independence and quality of life for the individual. Lifestyle recommendations for the prevention of osteoporosis have previously been developed and include guidelines for consuming adequate dietary calcium, ensuring adequate levels of vitamin D, limiting alcohol intake, avoiding smoking and undertaking weight bearing physical activity. However, these recommendations are not universally taken up or adhered to.

Previous research has reported a relationship between low health literacy and poor uptake of prevention behaviours in other chronic diseases; however, research regarding health literacy and prevention of osteoporosis is currently lacking.

Thus, the overarching aim of this thesis was to investigate potential associations between health literacy in women and osteoporosis prevention.

Methods

Health literacy data were collected using the multidimensional Health Literacy Questionnaire (HLQ), for women participating in the Geelong Osteoporosis Study (GOS) from December 2014 to March 2016 and for women participating in the 11 year follow-up of the Vitamin D in Pregnancy (VIP) Study from 2013 to 2016.

Additional data regarding sociodemographic characteristics, osteoporosis prevention behaviours and a diagnosis of osteoporosis according to self-report and bone mineral
density (BMD) criteria, were collected for women at the 15 year follow-up of the GOS from 2011 to 2014. Mothers in the VIP study also provided sociodemographic data and information regarding maternal and child osteoporosis prevention behaviours.

Analyses were undertaken to determine if health literacy scores differed between: women who adhered to osteoporosis prevention recommendations compared to those who did not, women who correctly self-reported osteoporosis status compared to those who did not, and mothers of children who participated in activities which promoted bone health compared to mothers of children who did not.

Analysis of variance was used to determine inter-group differences in health literacy scores, and effect sizes were calculated using Cohen’s D to determine the magnitude of differences between groups. Regression analyses were undertaken to investigate associations between health literacy and sociodemographic characteristics and to determine the relationship between sociodemographic characteristics, health literacy and osteoporosis prevention behaviours.

Results

In GOS women, lower health literacy scores were associated with older age, lower socioeconomic status (SES) and lower level of education. Additionally, lower health literacy scores were associated with inadequate dietary calcium intake, decreased physical activity levels and increased likelihood of smoking. Higher health literacy scores were associated with alcohol intakes above recommended levels, however, this association was attenuated by age and was likely explained by the inverse relationship between age and health literacy. No data were collected on vitamin D status.
Abstract

In older GOS women, lower health literacy scores were associated with a self-reported osteoporosis status that did not match BMD diagnosis of osteoporosis with the majority of women self-reporting no osteoporosis despite having met criteria for a clinical diagnosis of osteoporosis.

Finally, lower maternal health literacy was associated with decreased outdoor time but not calcium intake or screen time in children. For mothers, a trend was observed for a relationship lower health literacy and smoking but not dietary calcium or alcohol intake.

Conclusion

Together, these findings suggest that the health literacy of women may play a role in their ability to understand and adhere to osteoporosis recommendations, encourage behaviours that support bone health in their children, and recognise their own osteoporosis status. Health literacy should be a consideration in future initiatives to convey osteoporosis prevention recommendations to the wider community and in communicating a diagnosis of osteoporosis within a healthcare setting.
**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
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<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
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<tr>
<td>BMD</td>
<td>Bone Mineral Density</td>
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<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>BSD</td>
<td>Barwon Statistical Division</td>
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<tr>
<td>CI</td>
<td>Confidence Interval</td>
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<tr>
<td>DXA</td>
<td>Dual energy x-ray absorptiometry</td>
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<tr>
<td>ES</td>
<td>Effect Size</td>
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<td>EM</td>
<td>Expectation Maximisation</td>
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<tr>
<td>FFQ</td>
<td>Food Frequency Questionnaire</td>
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<tr>
<td>GOS</td>
<td>Geelong Osteoporosis Study</td>
</tr>
<tr>
<td>HLQ</td>
<td>Health Literacy Questionnaire</td>
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<tr>
<td>IQR</td>
<td>Interquartile range</td>
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<tr>
<td>IRSAD</td>
<td>Index of Relative Socioeconomic Advantage and Disadvantage</td>
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<tr>
<td>NHMRC</td>
<td>National Health and Medical Research Council</td>
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<tr>
<td>OR</td>
<td>Odds Ratio</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>SD</td>
<td>Standard Deviation</td>
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<tr>
<td>SEIFA</td>
<td>Socio-economic Indexes For Areas</td>
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<tr>
<td>SES</td>
<td>Socioeconomic Status</td>
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<tr>
<td>VIP</td>
<td>Vitamin D in Pregnancy</td>
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<tr>
<td>WHO</td>
<td>World Health Organization</td>
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</table>
Thesis Construct

Chapter One includes a narrative review which provides a background to the topic of osteoporosis and health literacy. This narrative review summarises the current published research in this field of enquiry while highlighting gaps in the literature and suggesting directions for future research. This chapter concludes with a list of aims for this thesis.

Chapter Two gives an overview of the methods used throughout this thesis and describes the two study population groups included in this thesis as well as the main data collection tools used throughout the thesis.

Chapter Three describes the health literacy profile of a group of women selected at random and participating in a longitudinal, population-based study. Associations between health literacy and a range of sociodemographic characteristics as well as lifestyle and anthropometric risk factors for chronic disease are investigated.

Chapter Four is an original research article published in BMC Research Notes (2015), which presents the results of pre- and post-test evaluation of knowledge change associated with a community-based information event. The event is an example of a novel method of presenting osteoporosis lifestyle prevention recommendations to engage participants and present information in a way which is accessible to individuals with a range of health literacy skills.

Chapter Five is a comment paper published in Journal of Nutrition and Food Sciences (2016). This paper describes the importance of, and barriers to, achieving adequate dietary calcium and suggests a greater understanding of the role health
literacy plays in achieving adequate dietary calcium may help to improve future interventions aimed at increasing dietary calcium intakes.

**Chapter Six** investigates associations between health literacy and the uptake of osteoporosis prevention recommendations in a longitudinal cohort study. Associations between Health Literacy Questionnaire (HLQ) scores and osteoporosis prevention behaviours including dietary calcium, alcohol intake, smoking and physical activity are presented and discussed.

**Chapter Seven** investigates associations between health literacy and agreement between self-report of osteoporosis status compared to bone mineral density results. Differences in HLQ scores between women who correctly self-reported their osteoporosis status compared to women who were unaware of their osteoporosis status are presented and discussed.

**Chapter Eight** is a letter to the editor published in *Journal of Bone and Mineral Research* (2016) in response to an editorial which detailed the poor uptake and adherence to osteoporosis medications. The letter suggests that health literacy is likely to play a major role in the ability of patients to make decisions about medication use and adhere to medication directives.

**Chapter Nine** investigates associations between maternal health literacy and uptake of osteoporosis recommendations in both mothers and children.

**Chapter Ten** brings together and discusses the main findings of the thesis as well as its strengths and limitations. Possible implications and future directions of this work are presented and the main findings of the thesis are briefly summarised in a conclusion.
Chapter One: Background and Aims
The role of health literacy in the prevention and management of osteoporosis across the lifespan: a narrative review

(Draft manuscript to be submitted to the journal ‘Bone’)
The role of health literacy in the prevention and management of osteoporosis across the lifespan: a narrative review

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**Keywords:** health literacy, osteoporosis, lifespan, prevention, management, fracture
Abstract

Osteoporosis and associated fragility fractures are costly, with the prevalence of osteoporosis likely to double over the next 30 years. Lifestyle recommendations exist for building and maintaining healthy bone throughout life, in order to prevent osteoporosis. Furthermore, a wide range of pharmacological therapies are now available for the management of osteoporosis, where clinically indicated. However, prevention and management recommendations regarding osteoporosis are not universally understood, or implemented by individuals. While the reasons for this are likely to be multi-faceted and complex, evidence suggests that health literacy may play a key role in the ability of individuals to access, understand and use information related to osteoporosis. Some evidence exists to indicate that skills and abilities related to functional health literacy are likely to be important to the effective prevention and management of osteoporosis. However, further health literacy research using more recently developed multi-dimensional health literacy tools is required to understand the health literacy strengths and weaknesses of populations and how they may affect the prevention and management of osteoporosis. This information would assist in addressing health literacy barriers in order to improve uptake of prevention messages and management recommendations.
Chapter One: Background and Aims

Background

Data from the 2010 Global Burden of Disease Study identifies osteoporosis, characterised by low bone mineral density (BMD), as a growing global health burden [1]. Bone mass is accrued during early life, peaks during adolescence and declines throughout the adult years [2]. The micro-architectural deterioration of bone tissue and BMD T-scores less than 2.5 SD below the young normal adult mean [3], as measured by dual energy x-ray absorptiometry (DXA), increases susceptibility to fracture [4]. Low BMD was attributed with 188 000 deaths and 5 216 000 disability adjusted life years (DALYs) in 2010 [1]. Globally, the number of people at risk of osteoporotic fracture is estimated to double over the next 30 years, rising from 157 million to 319 million by 2040 [5]. While population level screening is not justifiable, DXA scans are recommended for individuals who show specific risk factors for osteoporotic fracture including early menopause, long-term use of corticosteroids or prior fragility fracture [4]. Due to the higher prevalence of osteoporosis and fragility fracture associated with advancing age [1,5,6], a number of country-specific guidelines also recommend DXA scans for older individuals, usually aged 70 or over [2,7,8].

Osteoporosis prevention strategies and guidelines have been developed across the different regions of the world, and are broadly consistent in their recommendations [2,9–13]. As osteoporosis prevention guidelines share many commonalities with recommendations for the maintenance of general health, particularly with regards to nutrition, alcohol consumption and smoking, it could be assumed that the often widely-available recommendations would be easily understood by the general population. However, research has shown poor knowledge regarding osteoporosis prevention in a variety of different populations [14].
Chapter One: Background and Aims

For individuals who show certain risk factors for osteoporosis, undergoing a DXA scan and potentially treatment are recommended in addition to lifestyle prevention measures [8]. Currently, the uptake of DXA scans by at-risk individuals, and adherence to prescribed osteoporosis management directives, is less than optimal [15,16]. Although unknown, the reasons for low levels of osteoporosis knowledge, uptake of DXA scans and adherence to treatment are numerous and complex; indeed, the health literacy of individuals is likely to play an important role in both prevention and management.

Health literacy is an evolving concept that is gaining increasing attention in the public health sphere, especially given the important role it plays in influencing health behaviours associated with a wide range of health conditions [17,18]. The World Health Organization describes health literacy as not only the skills involved in accessing health information but also the abilities and motivation required to understand and apply health information in managing health [19]. Early health literacy tools including the Newest Vital Sign (NVS) [20] Test Of Functional Health Literacy in Adults (TOFHLA) [21] and the Rapid Estimate of Adult Literacy in Medicine (REALM) [22] failed to measure the broad set of skills identified by the World Health Organization. Instead, these early tools focussed on a narrow set of health-related literacy and/or numeracy abilities that are often referred to as functional health literacy [23]. Despite the limitations of early tools used to measure health literacy, previous research regarding health literacy and health outcomes does suggest a possible relationship between functional health literacy and a range of health outcomes. This research indicates that undertaking preventive and management tasks appear more difficult for those with poorer functional health literacy [24,25]. In the field of functional health literacy, very little evidence is available that specifically relates to osteoporosis. More recently, a number of multi-
dimensional health literacy tools have been developed that aim to measure multiple aspects of health literacy, enabling the development of more comprehensive interventions [26]. However, these tools are relatively new, and as such very little research has been published using these measures, particularly in the area of osteoporosis.

The advancements in the measurement of health literacy creates opportunities to explore the effect of a broad range of health literacy skills on the prevention and management of osteoporosis across the lifespan. This information would help to inform future interventions to improve bone health outcomes.

In order to inform future work, here we present a narrative synthesis of currently available evidence: our narrative format enables a discussion of highly heterogeneous studies, and identifies gaps in a relatively nascent area of research [27,28].

This narrative review will collate and discuss the influence of health literacy on osteoporosis prevention and/or management behaviours at different stages across the lifespan and from this narrative synthesis, suggest directions for future work.

**Health literacy and osteoporosis across the lifespan**

*Maternal influence on child bone health*

There is a growing body of evidence that suggests the risk of poor health outcomes associated with advancing age is partly attributable to the environment in utero; osteoporosis and associated increased risk of fracture is unlikely to be an exception [29–31]. Maternal lifestyle factors, such as inadequate diet and low vitamin D levels during pregnancy, have been associated with poorer bone health in neonates, and
observed during early childhood and into adulthood [29]. Furthermore, an increasing
evidence-base suggests that epigenetic mechanisms may transduce early life
exposures into future disease risk [30,32]. Such epigenetic changes are suggested to
be stable, and thus the effects may be trans-generational [32], further emphasising
the necessity to optimise maternal health during pregnancy to reduce the risk of
disease in future generations.

Prevention guidelines highlight the necessity for lifestyle prevention across all ages,
with particular emphasis placed on bone deposition in early life [2,11,12]. For this
reason it is important to recognise the role maternal knowledge and health
behaviours may play in to influencing offspring bone health as the child grows,
through health-related decision making for the child and modelling of health
behaviours [33,34]. While it is possible that maternal health literacy plays a role in
child bone health by influencing maternal knowledge and health behaviours, there is
currently a lack of research in this area. This reflects a wider problem with very little
research being undertaken into parental health literacy and its impact on child health
overall. There is some evidence to suggest that parents with poorer literacy skills (as
opposed to health literacy), or suboptimal functional health literacy, struggle to
perform basic health-related tasks for their children [35,36] This is particularly true
for parents from low socio-economic status (SES), culturally and linguistically
diverse (CALD) populations, or other disadvantaged or minority backgrounds
[36,37]. While this may point to an issue with comprehension of written information
in these groups, a greater understanding of the complexity and multi-faceted
elements of health literacy may illuminate alternate pathways for knowledge
translation in parents with poorer literacy skills.
Our current understanding of the link between basic literacy skills and child health outcomes is not sufficient to support parents in promoting offspring bone health. A greater understanding of the impact of a wide range of parental health literacy abilities on child health is required. This applies equally to overall child health but is particularly important in relation to bone health as bone mass acquired throughout early life is necessary to protect against osteoporosis later in life [38].

*Child, adolescent and young adult bone health*

As children grow older and develop their independence, ideally they begin to understand the importance of maintaining good health, and gradually take control over their health-related choices: these changes often occur during critical periods of growth and development [39]. For osteoporosis, these behaviours are particularly important throughout younger years [2], as peak bone mass (and thus the foundation for bone health later in life) is reached during early adulthood [40].

Due to the latent development of osteoporosis, and its asymptomatic nature prior to a fracture occurring, osteoporosis is likely to have low salience for adolescents; thus prevention is unlikely to be of interest to, or a priority for, individuals in this age group. Indeed, previous research has shown that knowledge about osteoporosis and preventive behaviours is limited in adolescents [41–44]. However, public health messages regarding the prevention of osteoporosis during this stage of life have commonalities with highly relevant messages regarding the maintenance of general health in this age group. These include; (i) regular physical activity to reduce the risk of physical and mental illness [45], (ii) smoking avoidance or cessation for general health, (iii) avoiding the consumption of alcohol or reducing alcohol intake for injury prevention [46,47] and (iv) the consumption of a varied diet that includes
calcium rich foods for obesity prevention and general wellbeing [48–50].

Understanding and implementing these behavioural messages requires the individual to possess a range of health literacy skills, thus the development of high-level health literacy abilities during childhood and adolescence is likely to be beneficial to health in adolescence, as well as providing a basis for adult health literacy [51]. To date, there has been little research undertaken with a specific focus on adolescent health literacy and bone health; however, a study Hill et al [52] included adolescents aged ≥15yrs in their investigation of health literacy and osteoporosis in adults. As data were combined for all ages, it is difficult to draw any conclusions regarding osteoporosis and adolescent health literacy.

The adolescent age group offers some unique opportunities for health literacy interventions. For instance, schools may provide a convenient capture of the target group, whilst the high uptake of online and social media in this group may enable more pathways for wider communication of health literacy education [39,53]. A 2011 review showed positive results for school-based intervention studies that aimed to increase adolescent health literacy; however, some caution is required in interpreting those findings [54]. Given that very few health literacy interventions had been undertaken with an adolescent population, only three studies were available to be included in that review. In addition, the tools used to measure health literacy in the adolescent populations were heterogenous with regards to the skills and abilities assessed: the studies used unidimensional functional health literacy tools including the TOFHLA and the REALM-teen [54]. Furthermore, the interventions employed were not specific to osteoporosis prevention or bone health-related outcomes, thus the effect of those interventions on the uptake of osteoporosis prevention messages in this age group remain unknown.
The common problem in determining health literacy levels across all life stages is that tools vary greatly with regards to the underlying constructs measured [55]. However, there is a severe lack of tools available to measure health literacy in childhood and adolescence. Thus, there are even fewer options to employ when attempting to understand health literacy in younger populations [51], whether this be for bone related outcomes or other health states. The scarcity of tools tailored to younger age groups is likely due to a lack of clear definitions as to what health literacy means for younger populations, and whether the purpose of those tools is to assist children and adolescents to manage their own health, to build a basis for adult health literacy, or both [51].

Development of a definition of and utility for health literacy in childhood and adolescence is essential in order to form a basis for the development of age- and population-appropriate tools [51]. Research undertaken using age appropriate, multi-dimensional tools to measure health literacy will enable us to develop a greater understanding of health literacy strengths and weaknesses in younger populations and understand the influence of health literacy on bone related health behaviours. This will in turn aid in the development of appropriate interventions to improve health literacy and uptake of osteoporosis prevention guidelines in this age group [39,51].

*Prevention of osteoporosis in adult populations*

As discussed with regards to the adolescent population, primary prevention strategies for maintaining bone health throughout adulthood are similar to those for many other lifestyle related health conditions. The avoidance of smoking is advocated for the prevention of many health conditions, and similarly applies to the prevention of
osteoporosis. Limiting alcohol intake is also advocated for bone health, although guidelines disagree as to the level of alcohol consumption considered low risk [56]. The consumption of calcium rich foods is incorporated in dietary guidelines recommended for promoting health [57] and regular physical activity across the lifespan is also recommended for general health [58]. However, the building and maintenance of strong bone requires weight bearing or resistance-based physical activity [2]; activity types that are not specifically advocated in all physical activity guidelines. Finally, adequate vitamin D exposure, gained from exposure to sunlight, has a strong association with good bone health, as well as playing a key role in the prevention of many other chronic health conditions [59].

Understanding primary prevention messages and implementing them for the maintenance of bone health requires a range of health literacy skills. Given this, it is not surprising that population subgroups with the lowest levels of health literacy are most likely to have the poorest bone health. As discussed, socioeconomic, cultural and language barriers and advancing age are associated with less than optimal health literacy (measured by both unidimensional and multidimensional health literacy tools) [37,60–62], and also with poorer bone health [63–65]. From this we may speculate that health literacy could be a mediating influence in the role each of these factors play in osteoporosis preventive behaviours in these group [66]. However, currently available research on health literacy and osteoporosis focuses on bone health outcomes such as osteoporosis or fracture. In order to intervene and prevent the development of osteoporosis, research is required to understand the role health literacy plays in not only knowledge of lifestyle guidelines for the prevention of osteoporosis but implementation of those guidelines in daily life.
Of the available literature investigating adult populations, many combine osteoporosis with other musculoskeletal conditions, thus making it difficult to discern the associations between health literacy and osteoporosis per se. For example, a review by Loke et al [67] identified five studies that used unidimensional health literacy tools to assess the impact of health literacy on musculoskeletal conditions and reported no significant association between health literacy and musculoskeletal disorders overall. Furthermore, the five studies used different health literacy tools that were heterogeneous with regards to the underlying constructs measured, and in the cut-off points used to estimate ‘low’ health literacy [68]. Conversely, a more recent example from Friis et al [69], showed a relationship between self-reported musculoskeletal disorders and two different aspects of health literacy as measured by two scales from a multi-dimensional health literacy tool in a population of 29,473 Danish adults (mean age=52.1 years, female=50.6%). This study found those who self-reported musculoskeletal disorders had poorer ability to understand health information and engage with healthcare providers than the general population. Similar to Loke et al [67] , Friis et al [69] did not break down the category of musculoskeletal disorders to show data for osteoporosis alone, thus, it is difficult to determine from this research if health literacy plays any role in the onset and/or management of osteoporosis specifically.

A publication by Hill et al [52] that distinguished between different musculoskeletal conditions, found that 70% of individuals from a population-based sample of Australian adults (≥15 years, female 51.8%) who self-reported osteoporosis had inadequate functional health literacy as measured by the NVS, whilst a lower proportion of those with arthritis or gout had inadequate levels of functional health literacy (50%). These findings indicate that by combining all musculoskeletal
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conditions, researchers may not obtain a clear picture of the different ways that functional health literacy is impacting on specific musculoskeletal conditions.

In efforts to enhance pre-existing uni-dimensional measures of health literacy, Rosenbaum et al [70] created the Literacy in Musculoskeletal Problems (LiMP) questionnaire to determine ‘the degree of inadequate musculoskeletal health literacy’. However, the LiMP questionnaire measures a narrow skill set, as it was designed to specifically evaluate knowledge of anatomy, terminology, diagnosis and treatment in musculoskeletal conditions. Furthermore, the analyses undertaken by Rosenbaum et al [70] combined all patients regardless of type of musculoskeletal condition, thus introducing a similar methodological problem as Loke et al [67] and Friis et al [69]. While it is important for clinicians to be aware that patient knowledge of musculoskeletal conditions may be limited when they are communicating essential health information, the LiMP tool reveals very little about the health literacy of a patient. A questionnaire such as this is likely to underestimate the abilities of newly diagnosed patients who may have the skills to find and use information in other contexts, but as yet have not needed to seek out anything relating to musculoskeletal disorders specifically. Conversely, the LiMP [71] is likely to overestimate the abilities of patients who understand terminology and treatments but face other barriers to taking up medical advice such as poor understanding of the need for treatment or a lack of social support for continued adherence to medical advice at home.

Taking these studies in context, the use of multi-dimensional measures of health literacy and research designs that differentiate between specific types of musculoskeletal disorders would assist in understanding associations between different health literacy skills and bone health outcomes. That level of information
would inform investigations regarding impact of health literacy on the prevention and management of different musculoskeletal conditions which may be symptomatic or asymptomatic, affect different age groups or require vastly different treatments.

**Management of osteoporosis in older adults**

Older populations, specifically women aged over 65 and men aged over 70, have the highest prevalence of osteoporosis, and are arguably the most likely to benefit from undergoing DXA scans and treatment, where clinically indicated [8]. Older populations are more likely to benefit from clinical intervention for their bone health, and are thus distinct from younger populations who may be more likely to benefit from lifestyle modifications that promote bone acquisition in early life and maintain bone over the life course. In addition, socio-economically disadvantaged older adults may be at greater risk of fragility fracture with a socioeconomic gradient of fragility fracture has been shown in some [63,72,73], but not all studies[74,75].

DXA scans are, in some countries, heavily subsidised for individuals at greatest risk of fragility fracture, particularly older populations [2,7,8]. However, those at greatest risk of fragility fracture do not always undertake practitioner recommended DXA scans and cost is not the only barrier. A recent systematic review [15] concluded there is evidence to suggest a relationship between lower SES and/or educational attainment and a reduced uptake of DXA scans. The authors reported that those of greatest social disadvantage were less likely to undergo DXA scans, even when there was no out-of-pocket cost to the patient. It may be that those populations at higher risk of suffering from a fragility fracture [63,76] are unaware that they have osteoporosis due to poorer uptake of DXA scans. Poorer uptake in disadvantaged population groups could potentially be attributable to poorer functional health
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literacy related to lower education levels, for example being unable to read and understand information on the availability of no-cost DXA scans. However, this is likely an over-simplification of the relationship between health literacy and social disadvantage. Disadvantaged populations are likely to face a range of barriers in accessing DXA scans beyond basic knowledge such as financial barriers associated with attending appointments (transport costs, time taken from work) as well as geographic barriers (where is the closest DXA scanner) and cultural barriers associated with accessing healthcare. Recognising these barrier and identifying methods to overcome them requires more complex ‘critical health literacy’ abilities that are not measured by unidimensional health literacy tools. The use of multidimensional health literacy tools is likely to assist in understanding the broader health literacy abilities and supports required to undertake DXA scans and thus direct future interventions to engage populations at greatest risk in this particular form of preventive health care.

For individuals who do undertake DXA scans, it is important they are able to comprehend what the practitioner tells them about their results so as to understand the imperative to adhere to management plans [16]. There is evidence to suggest that DXA results may be poorly understood, with a population-based study (mean age 58.6yrs, 51.8% male) demonstrating only 36% of participants with a BMD in the osteoporotic range self-reported having osteoporosis [77]. Medication adherence is also a well-documented issue for those with osteoporosis; it is estimated that between 30-50% of patients do not continue to take medications as recommended[78]. Health literacy may play a role in those who do and do not undergo DXA scans, and take up or adhere to treatments. As mentioned previously, individuals with lower functional health literacy have been shown to be less likely to undergo DXA scanning and/or to adhere to medications for other chronic conditions. Given the difficulty in supporting
individuals with lower health literacy to manage symptomatic conditions such as diabetes mellitus and cardiovascular disease, the challenge is likely to be even greater for a silent condition such as osteoporosis [79].

Similar to younger ages, few data exist regarding health literacy and osteoporosis in older adults. Of the studies available, and compared to younger populations, older adults were reported to have lower general health literacy scores as measured by the NVS or the TOFHLA, although achieved higher health literacy scores when measured by the REALM [68]. This discrepancy may be explained by understanding that the REALM only determines whether an individual can read and pronounce a set of health related words, including the word ‘osteoporosis’; however, that ability is not connected with understanding of the disease[80].

While we may expect that knowledge accumulation over time would result in older populations acquiring health literacy skills, the number of comorbidities a person must manage is also likely to increase with age [81], thus creating greater health literacy needs and complexity in self-management of diseases. Individuals are also more likely to experience cognitive impairment in later years [82], which has been shown to be strongly associated with functional health literacy in one study [83], although further research is required to understand the impact of cognitive impairment on a broader range of health literacy skills and abilities. Due to the complex care needs of older adults, it is particularly important that individuals in this age group have a set of core health literacy skills that can be broadly applied to a range of different conditions. It is equally important that healthcare providers are equipped with the skills and knowledge required to assist patients who face greater health literacy barriers. For this reason, the use of multi-dimensional health literacy tools, which explore a range of health literacy abilities applicable to a wide variety of
health challenges, is particularly pertinent: this knowledge will identify where to intervene to address health literacy barriers for better health-related outcomes.

**Strengths and limitations**

This narrative review summarises and discusses the current evidence available regarding health literacy and the prevention and management of osteoporosis across all life stages. Whilst our review discusses and contrasts much of the existing literacy, we acknowledge that our narrative review is not exhaustive. In addition, given that health literacy in the field of osteoporosis is a relatively nascent area of enquiry, care should be taken in drawing conclusions from this review. The information gained from health literacy research into other chronic conditions suggests an important role for health literacy in osteoporosis prevention and management. However, the asymptomatic nature of osteoporosis presents unique challenges in promoting, and increasing the uptake of prevention messages; thus the complex relationship between osteoporosis and health literacy is therefore likely to present unique challenges.

**Implications**

This review has highlighted the potential role health literacy may play in determining bone health across the lifespan and therefore likelihood of fracture in later life. Figure 1 illustrates the proposed relationship between health literacy and bone health throughout life. However, there is currently a paucity of research regarding health literacy and bone health, therefore, this review has highlighted areas for future work across a range of age groups. One common theme throughout this review is the need
for research that uses comparable multi-dimensional health literacy tools to understand the role of health literacy in osteoporosis prevention and/or management throughout life. Recommended research directions are listed in Table 1.

**Conclusion**

Osteoporosis and resultant fragility fracture are a costly and growing issue globally, thus, effective prevention and management is essential. However, there appears low uptake of prevention messages across different stages of life, and in those with osteoporosis, management directives are poorly adhered to. Although the evidence-base is limited, there is a suggestion for a relationship between health literacy and the ability of individuals to prevent and manage osteoporosis. Future research should use the more recently developed multi-dimensional measures of health literacy, so as to better understand the range of health literacy abilities required for the prevention and/or management of osteoporosis across the lifespan. This advancement in knowledge would enhance the ability of public health organisations and clinicians to tailor health communications and interventions toward addressing the health literacy barriers faced by populations in preventing or managing their osteoporosis.

**Acknowledgments**

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**Competing interests**
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References


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[77] A.L. Stuart, L.J. Williams, S.L. Brennan, M.A. Kotowicz, J.A. Pasco, Poor Agreement Between Self-Reported Diagnosis and Bone Mineral Density Results in
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Individual health literacy abilities and environmental supports influence uptake of lifestyle recommendations for prevention of osteoporosis in adults.

Child and adolescent health literacy begins to play a greater role in determining bone health promoting behaviours.

Age, SES and education level interact with health literacy to influence bone health across the lifespan.

Maternal health literacy influences offspring bone health in utero, during infancy and into early childhood.

Health literacy plays a role in the uptake of DXA scans and understanding of BMD results to influence awareness of osteoporosis status in older adults.

Health literacy influences uptake of management directives in individuals with osteoporosis.

**Figure 1:** The roles health literacy may play across the lifespan in determining fracture outcomes in later life.
Table 1: Directions for future research in health literacy and osteoporosis

<table>
<thead>
<tr>
<th>Life stage</th>
<th>Directions for future research</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maternal influence on child bone health</strong></td>
<td>Develop the evidence base regarding parental health literacy beyond the influence of basic literacy skills on child health. Understand the role of parental health literacy on offspring bone development through intrauterine development, decision making for the offspring during early childhood and role modelling of health behaviours.</td>
</tr>
<tr>
<td><strong>Child, adolescent and young adult bone health</strong></td>
<td>Identify a clear definition of what health literacy means in the adolescent population.</td>
</tr>
<tr>
<td></td>
<td>Creation of age-appropriate multidimensional health literacy tools</td>
</tr>
<tr>
<td></td>
<td>Develop an evidence base for health literacy in this age group on which future interventions may be built, including interventions to support bone development.</td>
</tr>
<tr>
<td><strong>Prevention of osteoporosis in adult populations</strong></td>
<td>Understand the impact of health literacy on the uptake of lifestyle guidelines for the prevention of osteoporosis, so as to intervene and potentially reduce the prevalence of osteoporosis.</td>
</tr>
<tr>
<td></td>
<td>Undertake health literacy research that differentiates between different musculoskeletal outcomes.</td>
</tr>
<tr>
<td><strong>Osteoporosis management in older adults</strong></td>
<td>Use of multi-dimensional health literacy tools to understand how best to address health literacy barriers and support older populations in managing a range of comorbidities, including osteoporosis.</td>
</tr>
</tbody>
</table>
Chapter One: Background and Aims

Thesis Aims
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Aims

The previous section identified a number of areas for future research regarding osteoporosis prevention across the lifespan. This research aims to address the substantial gaps in knowledge, as outlined in Table 1 of the previous narrative review, by investigating the role health literacy plays in the maternal influence on child bone health, the prevention of osteoporosis in adult women and also osteoporosis management in older women, in particular the ability to understand an osteoporosis diagnosis.

Specifically this thesis aims to:

1. Describe the health literacy of a randomly-selected, population-based sample of women and investigate associations between health literacy and sociodemographic characteristics in this group.
2. Investigate associations between health literacy and osteoporosis prevention behaviours in a randomly-selected, population-based sample of women.
3. Examine associations between health literacy and self-reported osteoporosis status compared to clinical diagnosis.
4. Provide a lifespan perspective on health literacy and bone health by investigating potential links between maternal health literacy profiles and bone promoting behaviours in children.

The overall objective of this thesis is to contribute to an evidence base informing the way osteoporosis recommendations are translated to the wider community.
Chapter Two: Methods
2. Methods

This chapter provides an overview of the two study populations and related data investigated in this thesis, and a description of the measurement tool used to collect health literacy data from these populations. Detailed descriptions of sample sizes, and analyses undertaken for each chapter are given within the methods section of individual chapters.

2.1 Health Literacy Questionnaire (HLQ)

The HLQ was self-completed by both women participating in the GOS and mothers participating in the 11 year follow-up of the VIP study.

The multidimensional Health Literacy Questionnaire (HLQ) (1) was developed to address limitations of previous health literacy measurement tools by encompassing all aspects of health literacy including individual abilities as well as the health literacy environment, including the accessibility of resources and healthcare.

The concepts of health literacy to be covered by the HLQ were generated in consultation with health experts and patients. Concepts were arranged into ‘domains’ with concepts that were similar or overlapped grouped together. Items were developed to measure each of the domains and cover the wide spectrum of health literacy skills.

A final review of items was undertaken by health experts before testing within a population based sample of individuals. Poorly performing items were removed with the remaining 44 items tested for reliability, readability and psychometric weakness (40). Each of the 44 items is a statement based around one of these nine constructs and is accompanied by one of two scales; the 4-item ‘strongly disagree’ to ‘strongly agree’ scale or the 5 item ‘cannot do’ to ‘very easy’ scale.
The domains included within the HLQ were:

1. Feeling understood and supported by healthcare providers
2. Having sufficient information to manage my health
3. Actively managing my health
4. Social support for health
5. Appraisal of health information
6. Ability to actively engage with healthcare providers
7. Navigating the healthcare system
8. Ability to find good health information
9. Understanding health information well enough to know what to do

The HLQ enables researchers to identify health literacy strengths and weaknesses at an individual, group or population level, thereby revealing in which areas that individual, group or population requires additional support. Identifying group profiles regarding health literacy better enables the targeting of interventions whether they occur at individual, group or at the population level, an ability that is lacking in currently widely used health literacy measurement tools. The HLQ has recently been successfully used in nine pilot sites across Victoria in order to identify the health literacy needs of their service users to inform the design and implementation interventions specifically tailored to address the health literacy needs of their service users (2).
2.2 The Geelong Osteoporosis Study (GOS)

The main study utilised throughout this project is Geelong Osteoporosis Study (GOS), an ongoing population-based cohort study involving more than 3,000 randomly-recruited adults (3). Using an age-stratified sampling technique, men and women resident in the Barwon Statistical Division were recruited using Commonwealth electoral rolls. A cohort of 1494 women were recruited in 1993-7 (77.1% participation) and participants have been assessed at baseline, 2-, 4-, 6- 8-, 10- and 15-year follow-ups. A new cohort of women (n=246) aged 20-29 years were additionally recruited at the 10 year follow-up of the original cohort and also participated in the 15 year follow-up. All GOS data included in this thesis were collected as part of the 15 year follow-up, with the exception of health literacy data which were collected after the completion of the 15 year follow-up undertaken from 2011 to 2014. Details of participation at all follow-ups have previously been published (3–5).

2.2.1 Participant Recruitment

All women enrolled in the GOS in December 2014 were invited to complete the HLQ either in paper version, or electronically, regardless of whether they had participated at 15 year follow-up. Of those women invited to complete the HLQ 713 women returned at least partial HLQ data, with details of participation numbers, including reasons for declining participation are outlined in Figure 2.1
Chapter Two: Methods

1494 Women at baseline

246 Women aged 20-29 added to cohort

232 Declined participation

945 Women eligible for inclusion

232 Declined participation

430 women died
85 Left region
2 Unable to consent
278 Unable to be

122 Personal reasons
12 Time restraints
74 Too old
22 Illness
2 Language barrier

713 Women returned HLQ

Figure 2.1: Participation details for the HLQ component of the GOS
2.3 GOS Questionnaire Data

A complete list of questionnaire data collected as part of the GOS has previously been published (3). This thesis includes questionnaire data collected at 15 year follow-up pertaining to diet, physical activity, smoking and osteoporosis status.

2.3.1 Assessment of Dietary Calcium and Alcohol Intakes

Dietary calcium and alcohol intakes were ascertained by Food Frequency Questionnaire (FFQ) previously developed by the Anti-Cancer Council of Victoria (6). The FFQ includes 112-items and asks participants to report how frequently they consume 74 different types of food and 6 types of alcoholic beverages on a 10 point scale. Participants are also asked to report the total number of standard drinks consumed usually in a day, as well as the maximum number of standard drinks consumed in a 24 hour period. Data provided on the FFQ are used to calculate estimates of daily nutrient intakes and average number of standard drinks consumed per day. Estimates of dietary calcium intakes from FFQs were categorised as adequate or inadequate using National Health and Medical Research Council (NHMRC) Recommended Dietary Intakes (RDIs) for calcium of: $\geq 1000\text{mg}$ for women aged 19-50 years old, and $\geq 1300\text{mg}$ for women aged $\geq 51$ years old (7). Similarly average alcohol intakes were categorised as within or exceeding NHMRC recommendations for alcohol intake of no more than two standard drinks per day (8).

2.3.2 Assessment of Physical Activity

Physical activity levels were self-reported in two ways; a six level mobility question and age-specific questionnaires which produce scores for three categories of physical activity (9,10).
Chapter Two: Methods

The mobility questionnaire asked participants to identify their usual activity level as one of seven different levels:

1. Very active
2. Active
3. Sedentary
4. Limited
5. Inactive
6. Chair or bedridden
7. Bedfast

This variable was dichotomised for analysis with levels 1 and 2 considered to be active and levels 3-7 considered sedentary.

From age-specific self-report questionnaires individual scores for physical activity were ascertained for three different types of physical activity: work/house work, sport and leisure. Details of these questionnaires have been published previously (9,10) and a more detailed description is provided in Chapter 6. Participants were categorised as <median score or ≥median score for each category of physical activity for analyses.

2.3.3 Assessment of Current Smoking

Participants were asked to report how many manufactured cigarettes, roll-your-own cigarettes, cigars, and pipes they smoked each day. Women selecting ‘0’ for all options were categorised as non-smokers.
2.3.4 Assessment of Co-morbidities

Chronic diseases, including osteoporosis status, were self-reported. Participants were asked to indicate which diseases they had been diagnosed with from a list of common illnesses.

2.3.5 Assessment of Education

Highest level of education was self-reported within the HLQ as one of five levels; ‘Primary school or less’, ‘High school (Incomplete)’, ‘High school (Complete)’, ‘TAFE/Trade’ and ‘University’.

2.4 Clinical Measures

2.4.1 Anthropometry

Height (±0.1 cm) was measured using a wall mounted stadiometer (Holtain Ltd, Britain) and weight (±0.1 kg) was measured using electronic scales and BMI calculated as (weight in kg)/(height in meters)$^2$. Waist circumference (minimal abdominal) was determined using an anthropometric tape measure and categorised as <80cm or ≥80cm, as per NHMRC guidelines (11).

Bone Mineral Density (BMD) was measured by DXA (Lunar DPX-L) and osteoporosis was defined as either a BMD T-score < -2.5 at the hip and/or spine (L2-L4), posterior-anterior projection).

2.4.2 Socioeconomic Status

Australian Bureau of Statistics (ABS) Socio Economic Indexes For Areas (SEIFA) for 2011 were used as an estimate of socioeconomic status (SES). The SEIFA ranks each Census Collection District, areas that encompasses approximately 250
households, according to measures of relative advantage and/or disadvantage. Whilst there are four SEIFA available, this thesis utilised the Index of Relative Social Advantage and Disadvantage (IRSAD): an index that encompasses measures of both advantage and disadvantage, thus providing information across the spectrum from the most disadvantaged to the most advantaged. Participant addresses were cross-matched with corresponding ABS collection districts in order to determine the IRSAD values, which were subsequently categorised into quintiles to determine area-level SES: whereby quintile 1 was the most disadvantaged and quintile 5 was the most advantaged.

2.5 Vitamin D in Pregnancy (VIP) Study

The second dataset encompassed in this thesis is a mother-child cohort recruited into the Vitamin D in Pregnancy (VIP) study, an ongoing longitudinal cohort study. Details of recruitment and previous follow-ups are published elsewhere (12). Briefly, women who were pregnant and <16 weeks gestation were recruited from the Geelong Hospital antenatal clinic over a period of 18 months beginning in 2002 and were subsequently followed up at: 32 weeks gestation, birth, one year, and 11 years of age. Data included within this thesis were collected as part of the 11 year follow-up of mother-child pairs which began in August 2013 and continued until January 2016. Of the 402 mother-child pairs enrolled in the study at the birth follow-up 209 (52%) returned for the 11 year follow-up. Maternal health literacy data was available for 194 mothers participating in the 11 year follow-up.

2.5.1 Maternal Measures

Dietary calcium and alcohol intakes were obtained and categorised using the same methods described above for the GOS population. Current smoking was self-reported
as number of cigarettes or pipes per day with mothers reporting 1 or more categorised as smokers. Self-reported highest education level was also obtained using the same question described for the GOS population above.

2.5.2 Measures of Child behaviours

Measures of child behaviours were also reported by mothers. Number of serves of five different calcium rich foods consumed in the previous 24 hours were reported by mothers. Children were categorised as either meeting or below Australian Dietary Guidelines for serves of calcium rich food of ≥3 serves/day for girls aged 9-11 years, ≥2.5 serves/day for boys aged 9-11 years and ≥3.5 serves/day for all children 12-13 years (13). Time spent outdoors during weekends and school holidays was reported as ‘2 hours or less’, ‘More than 2 hours’ or ‘Just about all day’. Children reported to be spending less than 2 hours outdoors were considered to be less likely to achieve adequate levels of vitamin D. Screen time was reported as hours per week watching television and hours per week playing electronic games and analysed as average hours per day. A previously used cut point of two hours per day (14) was used to categorise children into groups of low or high screen time.

2.6 Epidemiological Analysis

Detailed descriptions of all statistical analyses undertaken are given within the methods section of each chapter. In brief, one-way analysis of variance (ANOVA) and Cohen’s d effect sizes were used to determine whether differences exist between mean health literacy scale scores of two different groups (e.g. women who did vs women who did not meet calcium recommendations). This method has previously been utilised in analysing HLQ data (15). Regression analyses were used to
investigate relationships between HLQ scale scores and non-binary variables and to
determine the effect of sociodemographic characteristics on relationships between
HLQ scale scores and variables of interest.

With the exception of Chapter 4, which investigates the effectiveness of a novel
approach to translating osteoporosis prevention messages that catered to a range of
health literacy levels, research presented in this thesis is largely observational and
cross sectional in nature. This approach has enabled the identification of associations
between different aspects of health literacy and lifestyle behaviours for the
prevention of osteoporosis in a large, randomly selected population based cohort of
women. While this is an important first step in understanding the role health literacy
plays in the prevention of osteoporosis across the lifespan, further research is
required to understand how health literacy and health interact and influence one
another over time. For instance, does poor health literacy in youth result in poorer
health outcomes in old age? Does a new diagnosis affect an individual’s confidence
in their ability to find the health information they need, or in managing their health?
Future well-designed, longitudinal studies that include multidimensional measures of
health literacy are required to answer these questions.

In addition, while the research presented within this thesis provides some hints as to
how we may better translate osteoporosis prevention messages in ways which are
accessible, engaging and easily implemented for populations currently struggling to
take up these messages, robust intervention studies are required to test any strategies
informed by this early work.
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Chapter Three

Health literacy in a population based sample of Australian women: a profile of the Geelong Osteoporosis Study

(Draft manuscript to be submitted to the journal 'BMC Public Health')
Health literacy in a population-based sample of Australian women: a cross-sectional profile of the Geelong Osteoporosis Study

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Chapter Three

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Abstract

Background: The term health literacy refers to the abilities and resources required to find, understand and use health information in managing health. This definition is reflected in the recent development of multidimensional health literacy tools that measure multiple facets of health literacy. The aim of this study was to determine the health literacy profile of a randomly selected, population-based sample of Australian women using a multidimensional tool, the Health Literacy Questionnaire (HLQ). A second aim was to investigate associations between HLQ scales, sociodemographic characteristics and risk factors for chronic disease.

Methods: We surveyed women involved in the Geelong Osteoporosis Study (GOS), a longitudinal population-based study. We included demographic data, lifestyle information and anthropometric measures as well as the HLQ. The HLQ has 44 items, scored on either 4- or 5-point scales, within nine conceptually distinct scales. Means for each scale were calculated, and cross-sectional associations between HLQ domains and sociodemographic characteristics, and risk factors for chronic disease were investigated using regression analyses, analysis of variance (ANOVA) and calculation of effect sizes.

Results: The HLQ scale ‘Understanding health information well enough to know what to do’ displayed the highest mean score (mean 4.28, ±SD 0.54, possible range 1-5) while the scale ‘Appraisal of health information’ displayed the lowest (mean 2.81, ±SD 0.48, possible range 1-4). Lower health literacy in various scales, was associated with sociodemographic characteristics including older age, being born outside Australia and having three or more chronic health conditions. Biphasic associations were observed between health literacy and education level, as well as socioeconomic status (SES). Associations were also seen between lower HLQ scores
and poor health behaviours including smoking and being more sedentary, in addition to greater body mass index and waist circumference.

**Conclusions:** The profile of this population-based cohort of women demonstrated associations between low health literacy and low SES, lower levels of education, increasing age, and anthropometric and lifestyle risk factors for chronic disease. These associations between low health literacy and anthropometric and lifestyle risk factors for chronic disease were largely independent of age, education level and SES.

**Key words:** Health literacy, chronic disease, health inequities, sociodemographic
Background

Health literacy is described by the World Health Organization (WHO) as ‘the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health’ [1]. In the past, tools designed to measure health literacy have largely investigated different aspects of functional health literacy, a narrow set of basic literacy and numeracy skills applied to health [2–5]. However, measuring only functional health literacy fails to investigate the much broader range of abilities and resources an individual requires to effectively manage their health [6].

To address the limitations of earlier health literacy tools, recently several multidimensional tools have been developed that enable researchers to investigate a range of abilities and environmental factors associated with health literacy[7–10]. The Health Literacy Questionnaire (HLQ) is one multidimensional tool developed in Australia using a grounded approach [7]. Preliminary work has shown it has acceptable measurement properties[7,11], and it has been translated and used in many countries across the world [12–16].

Previous studies have measured health literacy using the HLQ in specific populations such as university students undertaking a health-related degree [16,17], recently hospitalised individuals [12,13] and patients with specific diseases, such as diabetes [18] and breast cancer [19]. Other than one Danish study that included two of the nine domains that make up the HLQ to assess health literacy in the general population [15]11, the full HLQ has not yet been applied to the general population.

There is an indication that health literacy may be a mediator in the relationship between certain sociodemographic characteristics and health behaviours and outcomes [20,21]. For instance, higher HLQ scores (better health literacy) have been
associated with health behaviours including healthier diet and increased physical activity [19,22], but not with alcohol consumption or smoking [22]. An understanding of health literacy in the wider population would assist in informing public policy, allocating resources and developing interventions to address low health literacy and reduce health inequalities at a population level [23].

The aim of this study was to describe the health literacy profile of a randomly recruited population-based sample of women participating in a cohort study based in south-eastern Australia. A second aim was to investigate whether there is any associations between HLQ domains and socio-demographic characteristics and risk factors for chronic disease

**Method**

**Participants**

Data were collected from women participating in the prospective, population-based Geelong Osteoporosis Study (GOS); the GOS protocol has been published elsewhere [24]. In brief, a cohort of 1,494 women was randomly recruited from the general population between 1993 and 1997 (77.1% participation) with a further 246 women aged 20-29 years recruited at the same time as the 10-year follow up. All participants enrolled in the GOS in December 2014 were sent the HLQ to complete, with data collection continuing until March 2016. All participants gave written, informed consent to be involved in the GOS. The Barwon Health Human Research Ethics Committee approved the study.

**Data collection**

Participants completed the HLQ online or via post. Participants who required assistance in completing the questions were given the opportunity to have a friend or
relative assist as well as being offered the option of completing the questionnaire over the phone with a member of the research team. A question within the HLQ itself captured information regarding whether or not participants had been assisted in completing the questionnaire and, if so, in what way they were assisted. Electronic data were collected via the Research Electronic Data Capture (REDCap) tool [25] hosted by Barwon Health, which was also used to enter and manage hard copy questionnaires.

The HLQ is a 44-item multidimensional tool that determines health literacy scores across nine conceptually distinct domains, each measured by an independent scale.

The nine scales that comprise the HLQ are:

1. Feeling understood and supported by healthcare providers
2. Having sufficient information to manage my health
3. Actively managing my health
4. Social support for health
5. Appraisal of health information
6. Ability to actively engage with healthcare providers
7. Navigating the healthcare system
8. Ability to find good health information
9. Understand health information well enough to know what to do [7].

Each scale includes between four and six items. Scales 1-5 encompass items scored on a 4-point scale (strongly disagree, disagree, agree, and strongly agree) and reflect an individual’s supports, motivation and confidence in managing their health. Scales 6-9 are scored on a 5-point scale (cannot do, very difficult, quite difficult, easy, and very easy) and broadly capture an individual’s capability to engage with, and use health information and health services, often based on lived experiences [7].
Data, including education level, health conditions, current smoking, possession of a healthcare card (a concession card available to individuals on low-income receiving government payments), private health insurance, and physical activity level (determined by a 5-level mobility scale and analysed as ‘active’ or ‘sedentary’), were self-reported. Highest level of education was recorded as one of five different levels (‘Primary school or less’, ‘Secondary education (not completed)’, ‘Secondary education (completed)’, ‘Technical and Further Education (TAFE)/Trade’ and ‘University’). Due to small counts in the lowest education group (n=28), the two lower levels of educational attainment were combined for analyses.

Alcohol consumption was determined using the Victorian Cancer Council Food Frequency Questionnaire [26] and categorised as meeting or exceeding National Health and Medical Research Council (NHMRC) of Australia guidelines of two standard drinks or less per day [27]. Height and weight were to the nearest 0.1cm and 0.1kg, respectively. Body mass index (BMI) was calculated as (weight in kg)/(height in metres)^2. Waist circumference (minimal abdominal) was measured using an anthropometric tape measure and categorised as <80cm or ≥80cm as per NHMRC guidelines [28].

Area based socioeconomic status (SES) was determined using the Australian Bureau of Statistic (ABS) Index of Relative Socio-economic Advantage and Disadvantage (IRSAD). The IRSAD is a calculation of the level of social advantage/disadvantage based on 2011 ABS census data for each ABS Census Collection District, an area that encompasses approximately 250 households. Participant residential addresses were matched with corresponding ABS collection district to determine values according to the Socio Economic Indexes For Areas (SEIFA), from which IRSAD scores were ascertained and used to categorise area-level SES into quintiles. In
accordance with an approach used previously [29], quintile 1 referred to the most
disadvantaged and quintile 5 was the most advantaged.

Analyses

Missing values for HLQ items were imputed using the expectation maximisation
(EM) algorithm, as previously employed by Beauchamp et al [12]. The EM
algorithm imputes values for scales where there are no more than 2 values missing
from 4-5 item scales and no more than 3 values missing from 6 item scales.

Effect sizes (ES) were calculated using Cohen’s d [30] for differences in mean HLQ
scale scores between demographic groups ES of 0.20 to 0.50, 0.5 to 0.80 and >0.80
were considered small, medium, and large, respectively. As HLQ scores were not
normally distributed we undertook analysis of variance (ANOVA) using the Welch
method to investigate differences in mean HLQ.

Regression analyses were used to investigate associations between HLQ scale scores
and non-binary sociodemographic characteristics. Associations between HLQ scores
and education level and SES quintile were presented as prediction means and p-
values. Binary logistic regression analyses were used to assess the relationship
between health literacy scale scores and anthropometric and lifestyle risk factors for
poor health outcomes, with sociodemographic variables including age, education and
SES, added to the models to assess their influence on associations.

Analyses were undertaken using SPSS version 22 and Minitab (version 16; Minitab,
State College, PA).

Results

Of 1,032 women sent the HLQ, 20 had died, 264 could not be contacted, and 35 did
not participate due to reasons including illness, age, time restraints and lack of
interest. Thus, 713 women provided HLQ data and were included in this analysis. Participants who required assistance in completing the questions were offered the option of completing the questionnaire over the phone. Twenty-six women were assisted to complete the questionnaire over the telephone and a further 16 women were assisted by a friend or relative.

Participant characteristics are presented in Table 1. Participant SES spanned all IRSAD levels, with similar proportions observed in the most disadvantaged (14.9%) and the most advantaged (16.9%) quintiles. Only 5 (0.71%) participants reported speaking a language other than English at home and 69 (10.4%) reported current smoking. Almost two-thirds of participants (n=435) had a BMI ≥25kg/m² and 464 (70.5%) had a waist circumference of ≥80cm.

Mean HLQ scale scores are shown in Table 2. The highest mean score for scales 1-5 was for Scale 1. ‘Feeling understood and supported by healthcare professionals’ (mean 3.20, ± SD 0.52) while the lowest mean score was observed for Scale 5. ‘Appraisal of health information’ (mean 2.81, ± SD 0.48). Scale 9. ‘Understand health information well enough to know what to do’ displayed the highest score of scales 6-9 (mean 4.28, ± SD 0.54), while Scale 7. ‘Navigating the healthcare system’ displayed the lowest mean score (mean 4.09, ± SD 0.57).

Tables 3 and 4 summarise the association between sociodemographic characteristics and anthropometric and lifestyle risk-factors, and the nine HLQ scales. ES observed for differences in mean HLQ scale scores between sociodemographic groups were all small (0.20 to 0.50). The largest ES was 0.45, which related to differences in mean scale scores for Scale 8. ‘Ability to find good health information’ between age <65 vs ≥65 years, self-reported health conditions <3 vs ≥3 (ES 0.45, 95%CI 0.41 to 0.57) and also sedentary vs active physical activity (ES 0.45, 95%CI 0.40 to 0.56). Being
born overseas was associated with lower mean scores in Scale 2. ‘Having sufficient information to manage health’ (ES 0.30, 95%CI 0.26 to 0.38) and Scale 8. ‘Ability to find good health information’ (ES 0.26, 95%CI 0.21 to 0.39). Having private health insurance was associated with higher mean scores in the greatest number of health literacy scales of any demographic characteristic, showing small but significant ES for all scales except Scale 5. ‘Appraisal of health information’. Private health insurance was also the only demographic characteristic that showed a significant ES for mean differences in Scale 1. ‘Feeling understood and supported by healthcare providers’ (ES 0.27, 95%CI 0.21 to 0.34).

Figure 1 illustrates the relationship between highest self-reported education level and health literacy scales. Associations for Scale 7. ‘Navigating the healthcare system’ and Scale 9. ‘Understand health information well enough to know what to do’ were biphasic. Women who did not complete secondary education and women with a TAFE or trade qualification showed lower mean scores than individuals who self-reported their highest level of education as secondary education (complete) or a university degree.

Figure 2 describes the associations between area-level SES and seven of the nine health literacy scales. Scale 5. ‘Appraisal of health information’ did not show any association while Scale 2. ‘Having sufficient information to manage health’ showed a non-linear trend (p= 0.05), with SES quintiles 3 and 5 showing an association with higher scale scores while holding quintile 1 as referent. All other scales showed a significant association, however, four of these associations were also biphasic.

Table 4 shows associations between lifestyle and anthropometric risk factors for chronic disease. Having a high BMI or waist circumference were both associated with lower scores in Scale 3. ‘Actively managing my health’ and Scale 4. ‘Social
support for health’. In regression analyses, after adjusting for SES, a high BMI was associated with higher scores in Scale 1. ‘Feeling understood and supported by healthcare providers’ (p=0.05). However, after adjusting for age and education, associations between waist circumference and Scale 2. ‘Having sufficient information to manage health’ were no longer seen, as shown in Table 5. Sedentary behaviour was associated with the greatest number of health literacy scales of any lifestyle or anthropometric risk factor for chronic disease and adjusting for age, education level or SES quintile did not change associations. A high alcohol intake was associated with higher mean scores for two health literacy scales, however, in binary logistic regression models adjusting for age, associations were no longer seen (Figure 2). A post hoc analysis revealed an association between age and alcohol intake, with a greater number of women in younger age groups (including women in their 30s, 40s and 50s) more likely to consume alcohol above recommended levels than women in older age groups (data not shown). Adjustment for education level or SES did not change associations (data not shown). Of the anthropometric and lifestyle characteristics investigated, smoking displayed the fewest associations with health literacy scales with one small ES seen for Scale 3. ‘Actively managing health’. This association remained after adjustment for age, education or SES in regression analyses.

Discussion

Women within this study displayed strengths and difficulties across nine domains of health literacy with mean scores varying across the HLQ scales. Sociodemographic characteristics including older age, lower education level, lower area-level SES, country of birth other than Australia, and increasing number of chronic health
conditions were all associated with lower health literacy. However, regression analyses revealed associations that appeared biphasic, between some HLQ scales and education level and SES quintile. Associations between anthropometric and lifestyle risk factors for poor health outcomes and lower health literacy remained after adjusting for age, education and SES. The exception to this was alcohol intake where associations between higher alcohol intake and higher health literacy were attenuated after age adjustment.

Sociodemographic characteristics

Age and country of birth have previously shown strong associations with multiple scales of the HLQ in Australian study populations [9,10]. However, our current study showed smaller ES and associations in fewer health literacy scales for both of these sociodemographic characteristics. Specific to country of birth, it is possible that language barriers were driving the effect seen between health literacy and country of birth in earlier studies, whilst the small proportion of participants in our study that did not speak English at home (0.7%) may explain why our results differed.

Previous research has revealed inconsistent associations between health literacy and social advantage and/or disadvantage. Associations between HLQ scale scores and SES and education vary between studies, possibly related to differences in the definition or measurement of parameters of social advantage/disadvantage, for instance income, occupation, highest level of education, or having private health insurance [13,15]. Completion of secondary education and greater number of years in education have both previously been associated with higher HLQ scores [12,13,15]. Our study found a similar relationship; however, we observed a biphasic relationship, with similar health literacy scores observed for the ‘TAFE/Trade’ group and the ‘Secondary education incomplete’ category. This suggests that education
type, in addition to time spent in formal education or completion of secondary education, may be important to health literacy. This speculation is supported by data from university students who undertook health-based degrees and showed varying HLQ scores across the different degrees [17]. Despite the fact that all participants in that study were attending university and were therefore more likely to have higher health literacy overall, the type of degree studied was still associated with HLQ scores with the highest HLQ scores observed for medical students and the lowest for nursing students [17].

The appearance of biphasic associations with area-level SES in our study may potentially be due to the use of SES quintiles derived from IRSAD data, which provide a greater level of detail compared to other studies that employed, for instance, 2- or 3-level measures of income [13,15]. Given that education and income variables form part of the aggregate IRSAD values, it may also be that education level, more so than income or other indicators of advantage/disadvantage, are underpinning these biphasic associations. This seems particularly likely in light of the well-documented interconnectedness between education and income, and the inextricable link between education, income and health literacy.

*Anthropometric and lifestyle risk factors*

Previous research has shown a greater likelihood of lower health literacy in individuals with a chronic health condition [12,18,32]. This may be explained by higher health literacy needs of individuals managing a chronic disease, or low health literacy leading to chronic illness, or both. We found associations between HLQ scores and anthropometric and lifestyle risk factors known to be associated with chronic diseases suggesting that health literacy may play a mediating role in the development of chronic disease. Associations between health literacy and
anthropometric and lifestyle risk factors for poor health outcomes were largely independent of sociodemographic characteristics usually associated with chronic illness including age, education level and SES.

The exception to this was the association between higher HLQ scores and alcohol intake above recommended levels. These associations were seen for the same HLQ scales which displayed an inverse association with age. In addition, after age-adjustment, associations between alcohol intake and HLQ score were not sustained. Thus, we undertook a post-hoc analysis to determine whether age was inversely associated with alcohol intake and, in keeping with previous research [33], we observed that younger women were more likely to exceed recommendations for alcohol intake. Together these results indicate that associations between higher HLQ scores and alcohol intake above recommended levels are likely driven by age. These results are similar to a previous study of Danish adults with diabetes in which no associations were seen between alcohol consumption and the two HLQ scales assessed, Scale 9. ‘Understanding health information well enough to know what to do’ and Scale 6. ‘Ability to actively engage with healthcare providers’, after adjusting for sociodemographic characteristics, including age [22].

While, associations between levels of physical activity and HLQ scores have been seen in a small study of 36 women diagnosed with breast cancer [19], and in a large (n= 29,473) population-based study of Danish adults with diabetes [22], HLQ scales associated with physical activity differed across those two studies and also our current study. These differences may be due to heterogeneous study populations and use of different measures of physical activity.

**Strengths and limitations**
Our study has a number of strengths. We utilised a population-based sample of women and a multidimensional measure of health literacy that enabled us to examine associations between specific aspects of health literacy and sociodemographic, anthropometric and lifestyle characteristics. The use of objective measures such as BMI and waist circumference are also a strength of this study.

A possible limitation of the study could be the underrepresentation of women with low health literacy due to the requirements of participation including the ability to read and understand the invitation to participate, complete questionnaires and attend clinical appointments. To mitigate this bias, we made efforts to offer assistance for completing questionnaires if needed. Similar to previous studies, we also avoided use of the term ‘health literacy’ in all communications to avoid the possibility that women with low literacy may have refused participation due to stigma or shame [14]. Data regarding smoking, physical activity and alcohol consumption were self-reported and are also subject to potential bias. Our current study was undertaken within a geographically defined area of regional Victoria, and thus results may not be generalisable to the wider Australian female population or to Australian men.

Conclusion

We used a multidimensional health literacy tool to describe the health literacy profile of a randomly selected, population-based sample of Australian women and investigate associations between health literacy and sociodemographic, anthropometric and lifestyle characteristics. Mean sores varied across the nine HLQ scales indicating women in this study have strengths and difficulties in different aspects of health literacy. We report associations between lower health literacy and sociodemographic characteristics including lower SES, lower levels of education, and having been born overseas. Unlike previous studies, the associations we
observed between health literacy and education and SES were biphasic, potentially
due to the different measures of education and SES used. We also demonstrated
associations between low health literacy and anthropometric and lifestyle risk factors
for chronic disease that were largely independent of age, education level and SES.
Further research in large population-based studies, using robust measures of lifestyle
risk factors is required to better understand the relationship between lifestyle
management of health and health literacy.

**Abbreviations**

ABS  Australian Bureau of Statistics  
ANOVA  Analysis of Variance  
BMI  Body Mass Index  
EM  Expectation Maximisation  
ES  Effect Size  
GOS  Geelong Osteoporosis Study  
HLQ  Health Literacy Questionnaire  
IRSAD  Index of Relative Socioeconomic Advantage and Disadvantage  
NHMRC  National Health and Medical Research Council  
REDCap  Research Electronic Data Capture  
SD  Standard Deviation  
SEIFA  Socio Economic Indexes For Areas
SES Socioeconomic Status

WHO World Health Organization

Declarations

Ethics approval and consent to participate

This research project was approved by the Barwon Health Human Research Ethics Committee (HREC) (Reference no. 92/01_E7). All participants gave written informed consent for participation.

Consent to publish

Not applicable

Availability of data and materials

The datasets analysed for the current study are available from the author Julie Pasco on reasonable request.

Competing interests

The authors do not have any competing interests to declare.

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Authors’ contributions
Author SMH led the data collection, analysis and preparation of drafts. Authors SLB-O, JAP, LJW and RB contributed to the initial conception of the study and provided ongoing guidance in facilitating the research. AB provided guidance for the data analysis strategy and JAP and SLB-O contributed to interpretation of results and initial drafts. All authors contributed to second and subsequent drafts and approved the final draft.

Acknowledgments

The authors would like to acknowledge the contributions of the research staff and participants of the Geelong Osteoporosis Study.
References


Table 1: Participant characteristics (n=713) given as n (%) or median (IQR)

<table>
<thead>
<tr>
<th>Demographic characteristics</th>
<th>n (%) or median (IQR)</th>
<th>missing data n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>59.1 (45.2-70.2)</td>
<td>0</td>
</tr>
<tr>
<td>Lives alone</td>
<td>138 (19.8)</td>
<td>16</td>
</tr>
<tr>
<td>Secondary education incomplete</td>
<td>240 (33.8)</td>
<td>2</td>
</tr>
<tr>
<td>Education (4 levels)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Secondary education (incomplete)</td>
<td>240 (33.8)</td>
<td></td>
</tr>
<tr>
<td>Secondary education (complete)</td>
<td>146 (20.5)</td>
<td></td>
</tr>
<tr>
<td>TAFE/Trade</td>
<td>141 (19.8)</td>
<td></td>
</tr>
<tr>
<td>University</td>
<td>184 (25.9)</td>
<td></td>
</tr>
<tr>
<td>Private health insurance</td>
<td>496 (71.0)</td>
<td>14</td>
</tr>
<tr>
<td>Health care concession card</td>
<td>283 (40.5)</td>
<td>15</td>
</tr>
<tr>
<td>Born in Australia</td>
<td>614 (86.2)</td>
<td>1</td>
</tr>
<tr>
<td>English spoken at home</td>
<td>706 (99.3)</td>
<td>7</td>
</tr>
<tr>
<td>IRSAD Quintiles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (most disadvantaged)</td>
<td>101 (14.9)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>72 (10.7)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>258 (38.2)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>131 (19.4)</td>
<td></td>
</tr>
<tr>
<td>5 (least disadvantaged)</td>
<td>114 (16.9)</td>
<td></td>
</tr>
<tr>
<td>≥3 Health conditions</td>
<td>143 (20.1)</td>
<td>22</td>
</tr>
<tr>
<td>BMI ≥25</td>
<td>435 (66.3)</td>
<td>57</td>
</tr>
<tr>
<td>Waist circumference ≥80cm</td>
<td>464 (70.5)</td>
<td>55</td>
</tr>
<tr>
<td>Sedentary activity</td>
<td>163 (24.5)</td>
<td>48</td>
</tr>
<tr>
<td>Current smoking</td>
<td>69 (10.4)</td>
<td>47</td>
</tr>
<tr>
<td>&gt;2 glasses alcohol per day</td>
<td>160 (24.1)</td>
<td>48</td>
</tr>
</tbody>
</table>

BMI = body mass index; IRSAD = Index of Relative Socioeconomic Advantage and Disadvantage
Table 2: HLQ scores for each of the 9 scales (n=712) given as mean with standard deviation (±SD), and 95% confidence interval (95%CI).

<table>
<thead>
<tr>
<th>Scale</th>
<th>HLQ Scale</th>
<th>Mean (±SD) [95%CI]</th>
<th>Missing data (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Feeling understood and supported by healthcare professionals</td>
<td>3.20 (0.52) [3.16, 3.23]</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Having sufficient information to manage my health</td>
<td>3.07 (0.44) [3.04, 3.11]</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Actively managing my health</td>
<td>2.99 (0.49) [2.95, 3.02]</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Social support for health</td>
<td>3.08 (0.50) [3.05, 3.12]</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Appraisal of health information</td>
<td>2.81 (0.48) [2.77, 2.84]</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>Ability to actively engage with healthcare professionals</td>
<td>4.17 (0.58) [4.13, 4.21]</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>Navigating the healthcare system</td>
<td>4.09 (0.57) [4.05, 4.13]</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>Ability to find good health information</td>
<td>4.11 (0.59) [4.06, 4.15]</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>Understand health information well enough to know what to do</td>
<td>4.28 (0.54) [4.24, 4.32]</td>
<td>9</td>
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</table>
## Table 3: Health literacy scores by sociodemographic characteristics

<table>
<thead>
<tr>
<th>Age</th>
<th>Score 1. Feeling understood and supported by healthcare providers</th>
<th>Score 2. Having sufficient information to manage my health</th>
<th>Score 3. Actively managing my health</th>
<th>Score 4. Social support for health</th>
<th>Score 5. Appraisal of healthcare information</th>
<th>Score 6. Ability to actively engage with healthcare providers</th>
<th>Score 7. Navigating the healthcare system</th>
<th>Score 8. Ability to find good health information</th>
<th>Score 9. Understanding health information well enough to know what to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;65</td>
<td>3.17 (0.55)</td>
<td>3.10 (0.44)</td>
<td>2.98 (0.53)</td>
<td>3.07 (0.51)</td>
<td>2.83 (0.49)</td>
<td>4.18 (0.55)</td>
<td>4.11 (0.54)</td>
<td>4.20 (0.51)</td>
<td>4.34 (0.48)</td>
</tr>
<tr>
<td></td>
<td>n=455</td>
<td>n=455</td>
<td>n=454</td>
<td>n=455</td>
<td>n=455</td>
<td>n=451</td>
<td>n=451</td>
<td>n=451</td>
<td>n=451</td>
</tr>
<tr>
<td>≥65</td>
<td>3.23 (0.46)</td>
<td>3.02 (0.42)</td>
<td>2.99 (0.40)</td>
<td>3.11 (0.48)</td>
<td>2.77 (0.47)</td>
<td>4.15 (0.61)</td>
<td>4.05 (0.64)</td>
<td>3.94 (0.68)</td>
<td>4.16 (0.62)</td>
</tr>
<tr>
<td></td>
<td>n=287</td>
<td>n=257</td>
<td>n=256</td>
<td>n=256</td>
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<td>n=253</td>
<td>n=252</td>
<td>n=252</td>
<td>n=253</td>
</tr>
<tr>
<td>Effect size for age (95%CI)</td>
<td>-0.12 (-0.06, -0.17)</td>
<td>0.19 (0.14, 0.24)</td>
<td>-0.02 (-0.07, 0.03)</td>
<td>-0.08 (-0.06, 0.13)</td>
<td>0.12 (0.08, 0.18)</td>
<td>0.05 (0.00, 0.13)</td>
<td>0.10 (0.05, 0.18)</td>
<td>0.45 (0.40, 0.54)</td>
<td>0.34 (0.29, 0.41)</td>
</tr>
<tr>
<td>Live alone</td>
<td>No</td>
<td>3.21 (0.51)</td>
<td>3.09 (0.43)</td>
<td>2.98 (0.49)</td>
<td>3.10 (0.49)</td>
<td>2.81 (0.47)</td>
<td>4.19 (0.55)</td>
<td>4.11 (0.54)</td>
<td>4.14 (0.56)</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3.17 (0.56)</td>
<td>3.04 (0.48)</td>
<td>3.02 (0.44)</td>
<td>3.03 (0.53)</td>
<td>2.79 (0.53)</td>
<td>4.11 (0.67)</td>
<td>4.04 (0.69)</td>
<td>3.99 (0.68)</td>
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<td></td>
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<td>n=137</td>
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<td>Effect size for live alone (95%CI)</td>
<td>0.08 (0.03, 0.17)</td>
<td>0.11 (0.08, 0.19)</td>
<td>-0.08 (-0.12, -0.01)</td>
<td>0.14 (0.10, 0.23)</td>
<td>0.04 (0.00, 0.13)</td>
<td>0.14 (0.09, 0.25)</td>
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<td>Born overseas</td>
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<td>-0.04 (-0.08, 0.06)</td>
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<td>0.14 (0.10, 0.20)</td>
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<td>0.13 (0.07, 0.19)</td>
<td>0.44 (0.39, 0.52)</td>
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<td>2.91 (0.48)</td>
<td>3.01 (0.56)</td>
<td>2.75 (0.49)</td>
<td>4.05 (0.64)</td>
<td>4.00 (0.63)</td>
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<td>0.22 (0.18, 0.30)</td>
<td>0.17 (0.12, 0.23)</td>
<td>0.30 (0.25, 0.31)</td>
<td>0.24 (0.20, 0.33)</td>
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<td>2.81 (0.48)</td>
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<td>≥3</td>
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<td>3.00 (0.54)</td>
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<td>2.94 (0.50)</td>
<td>2.80 (0.51)</td>
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<td>3.90 (0.71)</td>
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<td>n=565</td>
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<td>n=563</td>
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<td>Effect size for conditions (95%CI)</td>
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<td>0.06 (0.02, 0.14)</td>
<td>0.37 (0.33, 0.47)</td>
<td>0.02 (-0.02, 0.10)</td>
<td>0.33 (0.29, 0.45)</td>
<td>0.26 (0.22, 0.38)</td>
<td>0.45 (0.41, 0.57)</td>
<td>0.32 (0.28, 0.42)</td>
</tr>
</tbody>
</table>

Results in bold indicate a p-value <0.05 for difference in means tested using one-way ANOVA. ES calculated using Cohen’s d. ES are interpreted as “Small” >0.2-0.5, “Moderate” >0.5-0.8, “Large” >0.8.
Table 4: Mean health literacy scores (±SD) and effect sizes (95%CI) across anthropometric and lifestyle risk factors

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<tr>
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<th>Score range 1-4</th>
<th>Score range 1-5</th>
</tr>
</thead>
<tbody>
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<td><strong>BMI (kg/m²)</strong></td>
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<td></td>
</tr>
<tr>
<td>&lt;25</td>
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<td>4.19 (0.54)</td>
<td>4.16 (0.54)</td>
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<tr>
<td>3.11 (0.41)</td>
<td>4.13 (0.54)</td>
<td>4.29 (0.52)</td>
</tr>
<tr>
<td>≥25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.23 (0.49)</td>
<td>4.19 (0.56)</td>
<td>4.11 (0.57)</td>
</tr>
<tr>
<td>3.07 (0.43)</td>
<td>4.10 (0.54)</td>
<td>4.29 (0.50)</td>
</tr>
<tr>
<td><strong>Effect size for BMI (95%CI)</strong></td>
<td>-0.12 (-0.19, -0.07)</td>
<td>0.00 (-0.07, 0.05)</td>
</tr>
<tr>
<td>Waist circumference</td>
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<tr>
<td>&lt;80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.19 (0.52)</td>
<td>4.22 (0.54)</td>
<td>4.18 (0.52)</td>
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<td>3.14 (0.42)</td>
<td>4.14 (0.53)</td>
<td>4.34 (0.49)</td>
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<td>&gt;80</td>
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<td>4.08 (0.65)</td>
<td>4.11 (0.65)</td>
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<td>4.00 (0.68)</td>
<td>4.33 (0.56)</td>
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<td><strong>Effect size for waist (95%CI)</strong></td>
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<td>0.00 (0.04, 0.16)</td>
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<td></td>
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<td>4.27 (0.50)</td>
<td>4.25 (0.55)</td>
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<tr>
<td>3.09 (0.40)</td>
<td>4.24 (0.49)</td>
<td>4.33 (0.49)</td>
</tr>
<tr>
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<tr>
<td>3.26 (0.52)</td>
<td>4.08 (0.65)</td>
<td>4.11 (0.65)</td>
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<tr>
<td>3.03 (0.52)</td>
<td>4.00 (0.68)</td>
<td>4.33 (0.56)</td>
</tr>
<tr>
<td><strong>Effect size for sedentary (95%CI)</strong></td>
<td>-0.12 (-0.16, 0.04)</td>
<td>0.43 (0.39, 0.53)</td>
</tr>
<tr>
<td>Alcohol-drinks per day</td>
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<td>≤2</td>
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<td>4.17 (0.57)</td>
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<td>&gt;2</td>
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<td>3.24 (0.54)</td>
<td>4.20 (0.50)</td>
<td>4.38 (0.47)</td>
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<td>4.11 (0.65)</td>
<td>4.38 (0.47)</td>
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<td>n=159</td>
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<td>n=498</td>
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<td><strong>Effect size for alcohol (95%CI)</strong></td>
<td>-0.08 (-0.12, 0.00)</td>
<td>-0.24 (-0.29, -0.17)</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
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<td>3.22 (0.49)</td>
<td>4.17 (0.56)</td>
<td>4.11 (0.58)</td>
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<td>4.09 (0.57)</td>
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<td>4.17 (0.68)</td>
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<td>4.17 (0.59)</td>
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<td>4.17 (0.59)</td>
<td>n=69</td>
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<tr>
<td><strong>Effect size for smoking (95%CI)</strong></td>
<td>-0.20 (-0.16, 0.35)</td>
<td>-0.24 (-0.29, -0.12)</td>
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</table>

Results in bold indicate a p-value <0.05 for difference in means tested using one-way ANOVA.

ES calculated using Cohen’s d. ES are interpreted as “Small” >0.2-0.5, “Moderate” >0.5-0.8, “Large” >0.8.
Table 5: Unadjusted and age adjusted odds ratios (95% CI) for anthropometric and lifestyle factors across HLQ scales

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<thead>
<tr>
<th>Scale 1. Feeling understood and supported by healthcare providers</th>
<th>Scale 2. Having sufficient information to manage my health</th>
<th>Scale 3. Actively managing my health</th>
<th>Scale 4. Social support for health</th>
<th>Scale 5. Appraisal of health information</th>
<th>Scale 6. Ability to actively engage with healthcare providers</th>
<th>Scale 7. Navigating the healthcare system</th>
<th>Scale 8. Ability to find good health information</th>
<th>Scale 9. Understanding health information well enough to know what to do</th>
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</thead>
<tbody>
<tr>
<td><strong>BMI (kg/m^2)</strong></td>
<td><strong>Score range 1-4</strong></td>
<td><strong>Odds ratio (95% CI)</strong></td>
<td><strong>Score range 1-5</strong></td>
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<tr>
<td>&lt;25 vs ≥25</td>
<td>Unadjusted</td>
<td>1.31 (0.95, 1.81)</td>
<td>0.82 (0.56, 1.21)</td>
<td>0.47 (0.33, 0.67)</td>
<td>0.67 (0.48, 0.95)</td>
<td>0.77 (0.55, 1.07)</td>
<td>0.98 (0.73, 1.33)</td>
<td>0.91 (0.67, 1.24)</td>
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<td>Age Adjusted</td>
<td>1.28 (0.92, 1.77)</td>
<td>0.88 (0.60, 1.29)</td>
<td>0.46 (0.33, 0.66)</td>
<td>0.67 (0.48, 0.95)</td>
<td>0.79 (0.56, 1.12)</td>
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<td>0.92 (0.67, 1.25)</td>
<td>0.94 (0.69, 1.28)</td>
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<td><strong>Waist</strong></td>
<td><strong>Score range 1-4</strong></td>
<td><strong>Odds ratio (95% CI)</strong></td>
<td><strong>Score range 1-5</strong></td>
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<tr>
<td>&lt;80 vs ≥80</td>
<td>Unadjusted</td>
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<td>0.61 (0.41, 0.91)</td>
<td>0.46 (0.32, 0.66)</td>
<td>0.61 (0.43, 0.88)</td>
<td>0.78 (0.55, 1.11)</td>
<td>0.96 (0.71, 1.31)</td>
<td>0.86 (0.63, 1.17)</td>
</tr>
<tr>
<td>Age Adjusted</td>
<td>1.06 (0.76, 1.49)</td>
<td>0.67 (0.44, 1.01)</td>
<td>0.45 (0.31, 0.65)</td>
<td>0.61 (0.42, 0.88)</td>
<td>0.83 (0.58, 1.19)</td>
<td>0.98 (0.71, 1.34)</td>
<td>0.87 (0.62, 1.20)</td>
<td>0.83 (0.59, 1.15)</td>
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<td><strong>Sedentary</strong></td>
<td><strong>Score range 1-4</strong></td>
<td><strong>Odds ratio (95% CI)</strong></td>
<td><strong>Score range 1-5</strong></td>
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<tr>
<td>Yes vs No</td>
<td>Unadjusted</td>
<td>1.28 (0.89, 1.82)</td>
<td>0.73 (0.48, 1.10)</td>
<td>0.53 (0.37, 0.77)</td>
<td>0.86 (0.60, 1.23)</td>
<td>0.91 (0.64, 1.31)</td>
<td>0.66 (0.49, 0.90)</td>
<td>0.61 (0.45, 0.83)</td>
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<tr>
<td>Age Adjusted</td>
<td>1.23 (0.84, 1.78)</td>
<td>0.86 (0.56, 1.33)</td>
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<td>0.83 (0.57, 1.21)</td>
<td>1.02 (0.70, 1.50)</td>
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<td>0.64 (0.46, 0.89)</td>
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<tr>
<td><strong>Alcohol-drinks/day</strong></td>
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<td><strong>Odds ratio (95% CI)</strong></td>
<td><strong>Score range 1-5</strong></td>
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<tr>
<td>≤2 vs &gt;2</td>
<td>Unadjusted</td>
<td>1.18 (0.83, 1.68)</td>
<td>1.56 (1.02, 2.38)</td>
<td>1.24 (0.86, 1.80)</td>
<td>1.39 (0.96, 2.02)</td>
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<tr>
<td>Age Adjusted</td>
<td>1.30 (0.89, 1.89)</td>
<td>1.35 (0.87, 2.11)</td>
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<td>1.40 (0.95, 2.07)</td>
<td>1.08 (0.73, 1.60)</td>
<td>1.24 (0.87, 1.76)</td>
<td>1.31 (0.91, 1.89)</td>
<td>1.09 (0.75, 1.57)</td>
</tr>
<tr>
<td><strong>Smoking</strong></td>
<td><strong>Score range 1-4</strong></td>
<td><strong>Odds ratio (95% CI)</strong></td>
<td><strong>Score range 1-5</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes vs No</td>
<td>Unadjusted</td>
<td>0.70 (0.43, 1.12)</td>
<td>1.12 (0.63, 1.99)</td>
<td>0.52 (0.31, 0.86)</td>
<td>0.64 (0.39, 1.05)</td>
<td>0.90 (0.54, 1.50)</td>
<td>1.20 (0.76, 1.89)</td>
<td>1.31 (0.82, 2.09)</td>
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<tr>
<td>Age Adjusted</td>
<td>0.71 (0.44, 1.14)</td>
<td>1.05 (0.59, 1.87)</td>
<td>0.53 (0.32, 0.87)</td>
<td>0.64 (0.39, 1.04)</td>
<td>0.86 (0.51, 1.44)</td>
<td>1.18 (0.75, 1.87)</td>
<td>1.30 (0.81, 2.08)</td>
<td>1.06 (0.67, 1.69)</td>
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</tbody>
</table>

Results in bold indicate a p-value <0.05 for difference in means tested using regression analyses.
Chapter Four

Knowledge change regarding osteoporosis prevention: translating recommended guidelines into user–friendly messages

(Published in ‘BMC Research Notes’ 2015)
# AUTHORSHIP STATEMENT

## 1. Details of publication and executive author

<table>
<thead>
<tr>
<th>Title of Publication</th>
<th>Publication details</th>
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</thead>
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<tr>
<td>Knowledge change regarding osteoporosis prevention: translating recommended guidelines into user-friendly messages within a community forum</td>
<td>Published in <em>BMC Research Notes</em></td>
</tr>
<tr>
<td>Name of executive author</td>
<td></td>
</tr>
<tr>
<td>Sarah Hosking</td>
<td></td>
</tr>
<tr>
<td>School of Medicine</td>
<td><a href="mailto:shoskin@deakin.edu.au">shoskin@deakin.edu.au</a></td>
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</table>

## 2. Inclusion of publication in a thesis

<table>
<thead>
<tr>
<th>Is it intended to include this publication in a higher degree by research (HDR) thesis?</th>
<th>Yes</th>
<th>If Yes, please complete Section 3 if No, go straight to Section 4.</th>
</tr>
</thead>
</table>

## 3. HDR thesis author’s declaration

<table>
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<tr>
<th>Name of HDR thesis author if different from above. (If the same, write “as above”)</th>
<th>School/Institute/Division if based at Deakin</th>
<th>Thesis title</th>
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<tr>
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<td>School of Medicine</td>
<td>The role of health literacy in osteoporosis prevention</td>
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</table>

If there are multiple authors, give a full description of HDR thesis author’s contribution to the publication (for example, how much did you contribute to the conception of the project, the design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)

Alongside my co-authors I contributed to the initial development of the research question and design of the project as well as the data collection, data analyses and drafting and editing the manuscript.

*I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.*

Signature and date: L. Hosking 24/7/2017

## 4. Description of all author contributions

<table>
<thead>
<tr>
<th>Name and affiliation of author</th>
<th>Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)</th>
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<tr>
<td>Amella G Dobbins</td>
<td>Contributed to the data collection and drafting/editing of the manuscript.</td>
</tr>
<tr>
<td>Julie A Pasco</td>
<td>Was involved in the initial development of the research question and development of the methodology and contributed to the drafting/editing of the manuscript.</td>
</tr>
<tr>
<td>Sharon L Brennan-Olsen</td>
<td>Lead the development of the research question and design of the project and supervised data analysis as well as contributing to the drafting/editing of the manuscript.</td>
</tr>
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</table>
5. Author Declarations
I agree to be named as one of the authors of this work, and confirm:

i. that I have met the authorship criteria set out in the Deakin University Research Conduct Policy,
ii. that there are no other authors according to these criteria,
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<table>
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<td>26/7/17</td>
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<td>Julie A Pasco</td>
<td>[signature image]</td>
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6. Other contributor declarations
I agree to be named as a non-author contributor to this work.

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* If an author or contributor is unavailable or otherwise unable to sign the statement of authorship, the Head of Academic Unit may sign on their behalf, noting the reason for their unavailability, provided there is no evidence to suggest that the person would object to being named as author.

7. Data storage
The original data for this project are stored in the following locations. (The locations must be within an appropriate institutional setting. If the executive author is a Deakin staff member and data are stored outside Deakin University, permission for this must be given by the Head of Academic Unit within which the executive author is based.)

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<td>N/A</td>
<td>Julie A Pasco</td>
</tr>
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<td>Electronic Data</td>
<td>Excel Database, Barwon Health servers</td>
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<td>Julie A Pasco</td>
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If the publication is to be included as part of an HDR thesis, a copy of this form must be included in the thesis with the publication.
Knowledge change regarding osteoporosis prevention: translating recommended guidelines into user-friendly messages within a community forum

Sarah M Hosking¹, Amelia G Dobbins¹, Julie A Pasco¹² and Sharon L Brennan¹²*

Abstract

Background: Osteoporosis is a skeletal disorder characterised by low bone mineral density and increased fracture risk. Nationally the total costs of this chronic disease are currently estimated at $2.754 billion annually. Effective public health messages providing clear recommendations are vital in supporting prevention efforts. This research aimed to investigate knowledge change associated with the translation of preventive guidelines into accessible messages for the community.

Findings: We delivered a community-based information session that translated recommended guidelines for osteoporosis prevention into lay terms; items focused on dietary calcium, vitamin D, physical activity, alcohol, smoking and general osteoporosis-related knowledge. We developed a 10-item questionnaire reflecting these key points (score range 0–10) and investigated knowledge change associated with the session. Pre- and post-test questionnaires were completed by 47 participants (51% female), aged 21–94 years. Relatively high pre-test scores were observed for questions regarding sedentary activity and calcium intake. The lowest pre-test scores were observed for the item concerning whether swimming and cycling strengthened bones, and the highest possible score post-test was achieved for three of the items: calcium-rich food as a protective factor, and excessive alcohol and smoking as risk factors. The overall increase in knowledge change was a mean score of +2.08 (95%CI 1.58–2.42).

Conclusions: An increase in knowledge regarding osteoporosis prevention was demonstrated over the short-term. Our findings suggest that the guidelines concerning dietary calcium are generally well understood; however, the asymptomatic nature of osteoporosis and the types of physical activity that assist with bone strength are less well understood.

Keywords: Osteoporosis, Knowledge change, Recommended guidelines, Prevention

Background

Osteoporosis is a skeletal disorder characterised by low bone mineral density (BMD), microarchitectural deterioration of the bone and a subsequent increase in fracture risk [1]. Recent Australian data suggest that 330,000 women and 80,000 men have osteoporosis [2], and in the Geelong region specifically prevalence of osteoporosis has been estimated as 5.9% for men and 22.8% for women over the age of 50 [3]. Nationally, the total direct and indirect costs of this chronic disease are currently estimated at $2.754 billion [2], and set to increase dramatically in light of our ageing population. Effective public health messages that provide clear recommendations and develop osteoporosis-related knowledge are vital in supporting efforts in osteoporosis prevention. Although the modification of lifestyle behaviours may contribute significantly to reducing the risk of this disease, Australian communities have been reported in a number of studies as having a lack of knowledge about osteoporosis [4–7], and thus a limited ability to...
competently reduce their risk of this disease by modifying their lifestyles.

In efforts to address the increasing prevalence of osteoporosis, Osteoporosis Australia (OA) recently published an evidence-informed strategy for the prevention of this disease in the form of a consistent set of recommended guidelines [8]. The challenge is translating these comprehensive and evidence-based guidelines for a wider audience to ensure the messages reach beyond health professionals and are heeded by individuals who are at greatest risk of the disease.

World Osteoporosis Day was established by the International Osteoporosis Foundation in 1996, and is marked each year on October 20th by a variety of events in different countries aimed at raising awareness about the prevention, diagnosis and treatment of osteoporosis. We used this annual event as a platform to facilitate the translation of OA guidelines via an information session for the general community using visual and verbal tools. We aimed to investigate short term knowledge change associated with the translation of recommended preventive guidelines to accessible messages for the general community.

**Hypothesis**

We anticipated that the recommended guidelines translated into user-friendly messages presented in the form of a community-based information session, would increase participants’ knowledge of prevention messages.

**Methods**

**Participants**

Participants were recruited to attend a World Osteoporosis Day event in October 2013 using a convenience sample method. We delivered a community-based information session that translated the recommended guidelines for osteoporosis prevention; guidelines focused on dietary calcium, vitamin D exposure, physical activity, alcohol consumption, smoking and general understanding of osteoporosis. The event was open to the public and advertised broadly in the local newspaper as of interest to all adults, and fliers for the event were sent to participants (aged ≥50 years) enrolled in the Geelong Osteoporosis Study (GOS), a cohort randomly recruited from the Barwon Statistical Division (BSD), south eastern Australia [9]. Attendees at previous GOS public forums were also invited by mail to attend, and fliers were distributed to community groups in the BSD who assisted in the creation of an oversized jigsaw puzzle that was used as a communication tool during the information session [10]. Ethics approval was provided by Barwon Health Human Research and Ethics Committee; completion of the questionnaire was taken as implied consent for participation and aligned with ethical approval.

**Outcome measure**

We developed a 10-item questionnaire (see Table 1) that addressed the OA recommended prevention guidelines concerning osteoporosis [8]. Participants were asked to complete the questionnaire immediately prior to the information session, and again directly after the conclusion of the 40 minute information session. Participants had three possible response options for each of the 10 items on the questionnaire: True, False or Unsure. Research staff provided on-site assistance for vision impaired attendees who were unable to complete the questionnaire unaided; during the post-test, the assisting research staff members were blinded to pre-test responses. For analyses the questionnaire responses were coded as 1 if answered correctly, while incorrect and unsure responses were coded as 0.

**Statistical analyses**

Of the 48 attendees at the event, all but one had completed both the pre- and post-test questionnaire; thus, after excluding this individual, our sample included 47 participants.

The mean change in overall pre- and post-test scores was determined using a paired t-test. Paired t-tests were also performed to detect changes in mean scores for each item. Two of the 47 participants had missed answering one question, one at pre-test and one at post-test; to account for these missing data we applied a conservative approach consistent with the null hypothesis that no knowledge change would be achieved and

<table>
<thead>
<tr>
<th>10-item questionnaire addressing the OA recommended prevention guidelines concerning osteoporosis</th>
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<tbody>
<tr>
<td>Please read the following statements, and circle whether you think the statements are TRUE or FALSE. If you do not know the answer, please circle UNSURE</td>
</tr>
<tr>
<td>A diet low in calcium increases the risk of osteoporosis</td>
</tr>
<tr>
<td>We should include 3–5 serves of calcium-rich foods in our daily diet</td>
</tr>
<tr>
<td>Food is the main source of vitamin D</td>
</tr>
<tr>
<td>The body needs vitamin D to help absorb calcium</td>
</tr>
<tr>
<td>Excessive alcohol is bad for your bones</td>
</tr>
<tr>
<td>Activities like swimming and cycling help to build strong bones</td>
</tr>
<tr>
<td>People with osteoporosis can feel their bones getting weak</td>
</tr>
<tr>
<td>Long periods of sitting are good for bone strength</td>
</tr>
<tr>
<td>Cigarette smoking will harm your bones</td>
</tr>
<tr>
<td>Osteoporosis can affect men</td>
</tr>
</tbody>
</table>
carried the last value forward or backward for each of these individuals as appropriate. We also performed a sensitivity analysis after excluding the two participants who had each missed answering one item (n = 45). Significance was set at $p$-value $\leq 0.05$, and analyses were performed using Minitab (Version 16; Minitab, State College, PA, USA).

**Results**

Ages of the 47 participants (51% female) who answered both the pre- and post-questionnaire ranged from 21–94 years (median 60 years). The pre-test knowledge of our participants was a combined score of 336 out of a possible 470 (71.5%) vs. the post-test score of 430 (91.5%).

Table 2 presents the pre- and post-test scores for each of the 10 individual item themes together with the mean change in scores. The highest pre-test scores were observed for the following items: low dietary calcium as a risk factor (0.91, 95%CI 0.83, 1.00), 3–5 serves of calcium-rich food as a protective factor (0.94, 95%CI 0.86, 1.01), and long periods of sitting as a risk factor for osteoporosis (0.92, 95%CI 0.83, 1.00). The lowest pre-test scores were observed for the item that questioned whether swimming and cycling strengthened bones, for which the pre-test score was 0.06 (95%CI-0.10, 0.14). However, it was this latter item that showed the greatest mean increase of 0.70 (95%CI 0.57, 0.84). The highest possible score post-test was achieved by participants for three of the items: 3–5 serves of calcium-rich food as a protective factor, and excessive alcohol and smoking as risk factors. The overall mean change in knowledge scores was +2.08 (95%CI 1.58, 2.42). Our sensitivity analysis showed a similar mean increase in scores. Figure 1 presents the spread of participants showing a difference in total scores from pre- to post-test; the majority of participants increased their knowledge by between 1–3 points.

**Discussion**

We showed an increase in knowledge regarding osteoporosis prevention with pre- and post-tests performed immediately before and after the information session. This suggests that providing easily accessible messages to the general community can positively influence knowledge change regarding osteoporosis prevention. Our pre-test scores showed that, in general, recommended guidelines concerning dietary calcium intake are well understood; however, the asymptomatic nature of osteoporosis and the types of physical activity that strengthen bones are less well understood.

It is clear that the lifestyle behaviours involving dietary calcium, vitamin D exposure, physical activity, smoking and alcohol consumption influence the risk of osteoporosis [8], and given that these factors are all modifiable, they are often the prime focus of public health messages.

<table>
<thead>
<tr>
<th>Question Theme</th>
<th>Mean score (95%CI)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>Diet low in calcium is a risk factor</td>
<td>0.91 (0.83, 1.00)</td>
<td>0.94 (0.86, 1.01)</td>
</tr>
<tr>
<td>3–5 serves per day of calcium-rich foods are recommended</td>
<td>0.94 (0.86, 1.01)</td>
<td>1.00 (1.00, 1.00)</td>
</tr>
<tr>
<td>Sunlight is the main source of vitamin D</td>
<td>0.60 (0.45, 0.74)*</td>
<td>0.77 (0.64, 0.89)</td>
</tr>
<tr>
<td>Body needs vitamin D to help absorb calcium</td>
<td>0.79 (0.67, 0.91)</td>
<td>0.98 (0.64, 0.89)*</td>
</tr>
<tr>
<td>Excessive alcohol is a risk factor</td>
<td>0.79 (0.67, 0.91)</td>
<td>0.90 (1.00, 1.00)</td>
</tr>
<tr>
<td>Swimming and cycling do not build bone strength</td>
<td>0.06 (-0.01, 0.14)</td>
<td>0.20 (0.64, 0.89)</td>
</tr>
<tr>
<td>Osteoporosis is asymptomatic</td>
<td>0.47 (0.32, 0.62)</td>
<td>0.83 (0.72, 0.94)</td>
</tr>
<tr>
<td>Long periods of sitting are a risk factor</td>
<td>0.92 (0.83, 1.00)</td>
<td>0.92 (0.83, 1.00)</td>
</tr>
<tr>
<td>Smoking is a risk factor</td>
<td>0.79 (0.67, 0.91)</td>
<td>1.00 (1.00, 1.00)</td>
</tr>
<tr>
<td>Osteoporosis affects men</td>
<td>0.89 (0.80, 0.99)</td>
<td>0.96 (0.90, 1.02)</td>
</tr>
<tr>
<td>Change in total score (all items combined)</td>
<td></td>
<td>2.08 (1.57, 2.42)</td>
</tr>
</tbody>
</table>

*Missing data: n = 1 for each question at the time point indicated.
It is likely due to awareness-raising activities in the arenas of public health, media and primary and secondary care, that we observed high pre-test scores for questions concerning adequate dietary calcium and vitamin D levels. Similarly, participants had prior understanding that smoking and alcohol were risk factors for poor bone health and achieved a 100% score post-test. In light of the well-documented links between many other chronic diseases and alcohol use and smoking, it is plausible that participants readily accepted from our information session that this link also exists for osteoporosis. Finally, the pre-test scores regarding physical activity indicated that while most participants understood that sedentary activity was a risk factor for osteoporosis, very few understood the specific types of activities that improved bone strength. Despite this latter item showing the greatest increase in knowledge change, it nevertheless remained one of the two lowest scoring items post-test. The lack of understanding regarding types of physical activity beneficial for bones may stem from the fact that the guidelines for osteoporosis prevention differ from the guidelines for general well-being where aerobic physical activity is considered positive for health [11], while weight bearing activities are useful for strengthening bones [8].

The pre- and post-test scores indicated that participants had a reasonably sound understanding that osteoporosis affects both sexes. In contrast, prior to the information session, less than half of the participants were aware that osteoporosis is often asymptomatic prior to a fracture occurring. It is of public health concern that, despite much research and media attention, many individuals remain unaware of the asymptomatic nature of osteoporosis and thus plausibly will disregard the need for preventive behaviours or health-related advice in the absence of symptoms. The limited community awareness regarding osteoporosis being asymptomatic pre-fracture has previously been reported, for instance Francis et al. [12] in 2009 and Solomon et al. in 2006 [13]; clearly, our targeted efforts during the last few years to raise awareness about osteoporosis being the 'silent disease' need to continue on a broad scale. It is imperative that public health remains focused on osteoporosis prevention per se rather than only directed toward those who have already fractured. Given that deficits in osteoporosis-related knowledge have also been reported in general practice [14,15], influencing a shift in the community's understanding of osteoporosis will assist in sharing the role of osteoporosis prevention between multiple players.

One of the strengths of this study was that our information session and the 10-item questionnaire were developed to reflect the most recent OA guidelines [8]. Whilst we employed a convenience sampling method for recruitment, we aimed to include a larger age range of participants by specifically targeting the invitations to increase attendance by older individuals from across the BSD. Our information session resulted in a significant increase in knowledge change for 87% of the participants. However, we also acknowledge that five individuals did not show an improvement and one participant showed poorer knowledge following the information session; we speculate that this may be explained by poorer cognitive functioning and/or hearing in some of our older participants. This study also has some limitations. Due to the small sample size involved in this study we acknowledge that our findings might not be generalisable to other groups or populations; however, we are unable to comment further on this as no data pertaining to osteoporosis status or demographics were obtained. It is also possible that the differences we detected in knowledge change may be due to the participation bias inherent in a self-selected sample such as ours. We speculate that attendees who chose to be involved may have had different levels of knowledge prior to the information session and/or different post-test scores compared to the general population, due to a potential higher level of interest in the topic and a willingness to learn. The short time between the information session and the post-test questionnaires meant that only short-term knowledge change could be examined and thus we cannot speculate on the longer term benefit of the forum. However, previous studies have shown that even single sessions can result in a sustained improvement in knowledge [16]. We also acknowledge that increased knowledge is but one component of intervention strategies that are important for influencing behavioural change [17]. Finally, the 10-item questionnaire used to examine knowledge change was developed by researchers for this specific purpose, and has not been validated. Nevertheless, it is important to stress that the questions were based on current recommended guidelines.

Conclusion
In conclusion, we focused our information session on translating into lay terms the currently-recommended guidelines regarding osteoporosis prevention for the general community and demonstrated an increase in knowledge change over the short-term. Based on our pre-test observations, we recommend that public health messages should continue to raise awareness regarding the asymptomatic nature of osteoporosis, and provide greater clarity about the types of physical activity that target bone. It is imperative that the recommended guidelines for osteoporosis prevention are translated into accessible messages for the public.

Abbreviations
BMD: Bone mineral density; BSD: Barwon statistical division; GOS: Geelong osteoporosis study; OA: Osteoporosis Australia.
Competing interests
The authors declare that they have no competing interests.

Authors’ contributions
All authors conceived the event and participated in the study design. JAP, SWH and SLB developed the questionnaire. All authors participated in delivering the event. SWH performed the statistical analysis. All authors assisted with the interpretation of the results, and read and approved the final manuscript.

Acknowledgements
SLB is supported by NHMRC Early Career Fellowship (GNT1012472). We thank Dr Stephen E Lane, Barwon Health, for providing statistical advice.

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Published online: 08 February 2015

References
Chapter Five

Recommendation for Dietary Calcium intake and Bone Health: the Role of Health Literacy

(Published in the 'Journal of Nutrition and Food Sciences' 2015)
AUTHORSHIP STATEMENT

1. Details of publication and executive author

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<th>Email or phone</th>
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<tr>
<td>Sarah Hosking</td>
<td>School of Medicine</td>
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</table>

Alongside my co-authors I contributed to the initial concept of the publication as well as drafting and editing the manuscript.

*I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.*

4. Description of all author contributions

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<th>Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)</th>
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<tr>
<td>Julie A Pasco</td>
<td>Contributed to the drafting and editing of the manuscript</td>
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<tr>
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<tr>
<td>Sharon L Brennan-Olsen</td>
<td>Contributed to the development of the initial concept for this publication as well as drafting and editing of the manuscript</td>
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I agree to be named as one of the authors of this work, and confirm:

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<td>Sharon L Brennan</td>
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This form must be retained by the executive author, within the school or institute in which they are based.
If the publication is to be included as part of an HDR thesis, a copy of this form must be included in the thesis with the publication.
Recommendations for Dietary Calcium intake and Bone Health: the Role of Health Literacy

Hosking SM1, Pasco JA1,2, Hyde NK1, Williams LJ1 and Brennan-Olsen SL1,3,4,*
1School of Medicine, Deakin University, Geelong, 3220, VIC, Australia
2School of Medicine, the University of Melbourne, Parkville, 3000, VIC, Australia
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4Institute for Health and Ageing, Australian Catholic University, Melbourne, 3000, VIC, Australia
*Correspondence author: Brennan-Olsen SL, Health Inequities Division of Epidemiology, Epi-Centre for Healthy Ageing, IMPACT SRC, School of Medicine, Deakin University, PO Box 281, VIC 3220, Australia, Tel: 610342153334; E-mail: sharobbarwonhealth.org.au

Rec Date: Nov 22, 2015; Acc Date: Dec 16, 2015; Pub Date: Dec 28, 2015

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Abstract

Osteoporosis is a skeletal disease that involves micro-architectural deterioration of the bone matrix and depletion of bone mineral. Inadequate dietary calcium, especially in a vitamin D deficient environment, may predispose an individual to osteoporosis. Given that recommendations for daily intake (RDI) of dietary calcium differ between countries, and according to life-stages, understanding RDIs and how to achieve them is likely to be a complex process for many individuals. Health literacy, or the ability of individuals to gain access to, understand and use health-related information, will influence the capacity of individuals to meet RDIs. Furthermore, the lowest health literacy is observed in the same groups identified as having an increased risk of osteoporosis; older individuals, and those that are socially disadvantaged. It is imperative to consider the specific health literacy needs of at-risk populations when promoting recommendations for dietary calcium intake.

Keywords: Health literacy; Dietary calcium intake; Osteoporosis; Recommended daily intake

Health Literacy

Osteoporosis, a common disease of the skeleton, involves micro-architectural deterioration of the bone matrix and depletion of bone mineral; this results in an increased susceptibility to fracture [1]. Post-fracture, there is a plethora of financial, personal and psychosocial outcomes, including reduced mobility, impairment of daily activities, inability to work and loss of confidence [2,3]. A hip fracture has the most severe implications: one in five individuals die within the first year, while 60% of individuals who survive a hip fracture still require assistance to walk one year later, and 33% are totally dependent or are admitted to a nursing home [2,4]. Bone mass is an important predictor of osteoporosis, and future fracture risk [5], and calcium plays an important role in normal growth, development and maintenance of the skeleton [6], including providing a dynamic store to maintain the intra- and extra-cellular calcium pools [7]. Calcium homeostasis is regulated by an integrated hormonal system that involves calcitonin, parathyroid hormone (PTH) and the PTH receptor, and 1,25-dihydroxyvitamin D and the vitamin D receptor [7,8], along with serum ionized calcium, and the calcium-sensing receptor [9]. When plasma concentrations of ionized calcium fall below optimal levels, bone resorption increases in order to restore the mineral equilibrium.

Clearly, adequate dietary calcium intake is an essential modifiable dietary factor for both achieving optimal peak bone mass in the second to third decade of life [10] and reducing age-related bone loss in later life [11]. However, recommendations for daily intake (RDI) of dietary calcium differ between countries; such discrepancies may likely arise from the rationale implemented by the governing bodies with responsibility for nutritional RDIs [12].

<table>
<thead>
<tr>
<th>Life-stage</th>
<th>RDI (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Babies 0-6 months</td>
<td>~210 (if breastfed)</td>
</tr>
<tr>
<td></td>
<td>~350 (if formula fed)</td>
</tr>
<tr>
<td>Babies 7-12 months</td>
<td>270</td>
</tr>
<tr>
<td>Children 1-3 years</td>
<td>500</td>
</tr>
<tr>
<td>Children 4-8 years</td>
<td>700</td>
</tr>
<tr>
<td>Children 9-11 years</td>
<td>1,000</td>
</tr>
<tr>
<td>Adolescents 12-18 years*</td>
<td>1,300</td>
</tr>
<tr>
<td>Women 19-50 years*</td>
<td>1,000</td>
</tr>
<tr>
<td>Women 51-70 years</td>
<td>~1,300</td>
</tr>
<tr>
<td>Men 19-70 years</td>
<td>1,000</td>
</tr>
<tr>
<td>Adults over 70 years</td>
<td>~1,300</td>
</tr>
</tbody>
</table>

Table 1: Recommended dietary intake (RDI) of calcium in Australia and the United States of America, at different life-stages [13,14,25].

*Including pregnant and breastfeeding women.

For instance, whilst RDI guidelines from the United Kingdom (UK) were formulated to address nutritional needs of the population as a whole, countries such as the United States of America (USA) and Australia targeted guidelines to address fluctuations in needs related to growth and development of bone health across the life-course [13,14].
Table 1 presents the RDI s for dietary calcium according to guidelines from Australia and the USA [13,14] notably these differ from European guidelines [15] and those of the UK, which appear much lower than the RDI s from Australia and the USA.

Given the differences in RDI s according to life-stages [6], understanding RDI s and how to achieve them is likely to be a complex process for many individuals. Furthermore, health promotion messages regarding adequate dietary calcium intake differ between official vs. commercial avenues, and diffusion processes also vary, including presentation via written, oral and/or visual medium/s. The ability to decipher nutrition labels and understand how to source calcium rich food adds yet another complexity to the likelihood of meeting RDI s. As such, achieving RDI s is dependent upon the capacity of individuals to access, comprehend and apply the recommended guidelines. Studies have shown that many in the general population do not meet RDI s for dietary calcium [16,17]; however, the groups most unlikely to meet RDI s are older individuals, and the socially disadvantaged [16]; in English speaking countries, this may also include those of non-English speaking backgrounds (NESB).

Health literacy is defined by the World Health Organisation as the “cognitive and social skills, which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health” [18]. Health literacy skills influence the uptake of health promotion messages. The measurement of health literacy is complex, and, to date, most research in this field has been undertaken using measurement tools that focus on a narrow definition of health literacy, for instance focusing on language or numeracy skills [19]. These narrow definitions of health literacy, and the application of different measurement tools, may underpin the high variability in prevalence of sub-optimal health literacy reported within the literature [20]. For instance, studies that applied the Newest Vital Sign (NVS), and the Rapid Estimate of Adult Literacy in Medicine (REALM) tools, showed that older populations have lower health literacy compared to younger populations [21]; however, the opposite was observed when the Test of Functional Health Literacy in Adults (TOFHLA) was employed [21]. To address the variability and short falls in these older unidimensional measurement tools, recently developed tools encompass a broader range of health literacy skills and abilities; these include the Health Literacy Management Scale (HeLMS) [22], Health Literacy Questionnaire (HLQ) [23], and the European Health Literacy Survey Questionnaire (HLS-EU-Q) [19]. Despite the limitations of older unidimensional health literacy tools, there was relative consistency in the suggestion that certain populations have different health literacy needs. Those with lower health literacy skills are the same groups at increased risk for osteoporosis, and subsequent fracture.

Taken in context, it is clear that health literacy plays an important role in health promotion. In order to increase the proportion of individuals that meet RDI s for dietary calcium, we need an improved understanding of how older individuals, those that are socially disadvantaged, and those from NESB, obtain, understand and use health information. By taking into account the health literacy strengths and weaknesses of these subgroups, it will enable us to inform the development of more appropriately targeted interventions, and therefore will improve the accessibility and comprehension of RDI messages for at-risk individuals. As an example, data collected using a multi-dimensional health literacy measurement tool suggests that older individuals are more likely to have a higher than average level of social support [24], thus health messages channelled through (non-electronic) social networks may be efficacious. Similarly, individuals with lower educational attainment (a parameter of social disadvantage) are more likely to have difficulties finding, understanding and appraising health information [24], thus messages aimed at this group need to be presented in simple, user friendly formats. Finally, individuals of NESB have a reduced capacity to understand health information presented via mass media [24]; thus, resources in a variety of languages are necessary. However, data also suggested that the distribution of these resources within healthcare settings for individuals of NESB may not influence behaviour change, as this group also had a reduced capacity to navigate healthcare systems [24].

In conclusion, the majority of public health campaigns aimed at promoting adequate dietary calcium intake are likely to have limited impact on those at greatest risk, if the important role played by health literacy in the likelihood of individuals meeting RDI s is ignored.

Acknowledgements/Funding

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Conflict of Interest

None declared.

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Chapter Six

Health literacy and the uptake of osteoporosis prevention recommendations in a population-based sample of Australian women

(Draft manuscript to be submitted to ‘Journal of Bone and Mineral Research’
Health literacy and the uptake of osteoporosis prevention recommendations in a population-based sample of Australian women

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Abstract

Background

The uptake of best-practice recommendations for preventing osteoporosis is currently suboptimal. We investigated the role of health literacy in the uptake of prevention guidelines regarding physical activity, smoking, alcohol consumption and dietary calcium.

Methods

Data were collected for 676 women (age range 28-89 years), participating in the Geelong Osteoporosis Study (GOS): a population-based cohort study in south-eastern Australia. Health literacy was ascertained using the Health Literacy Questionnaire (HLQ), a multi-dimensional tool that generates scores across nine domains of health literacy. Data concerning physical activity, smoking, alcohol consumption and dietary calcium were collected by questionnaire. Participants were considered as meeting osteoporosis prevention recommendations if they were a non-smoker, achieved physical activity scores at or above the median, met NHMRC Recommended Dietary Intake (RDI) for calcium and consumed ≤2 alcoholic drinks/day. Effect sizes (ES) were calculated for differences in mean HLQ domain scores between participants who did compared to those who did not meet each recommendation. Regression analyses were used to determine the effect of sociodemographic characteristics on associations between the nine domains of health literacy and osteoporosis prevention behaviours.

Results

Among 676 women, 69 (10.4%) were smokers, 160 (24.1%) consumed >2 standard drinks and 557 (85.0%) did not meet calcium RDIs. Meeting calcium RDI was associated with higher scores in HLQ domains relating to finding, or having, sufficient health information, independent of sociodemographic characteristics. Conversely, higher scores in HLQ domains
that related to finding, having, and understanding health information were associated with exceeding alcohol intake recommendations; however, this association was not independent of age. Lower scores for the domain of ‘Actively managing health’ were associated with current smoking. Associations between a number of health literacy domains and different types of physical activity were observed. In particular, moderate ES were observed for differences in HLQ scores between women achieving scores in the ‘sport’ and ‘leisure’ categories of physical activity at or above the median compared to below the median.

Conclusion

These results suggest that particular health literacy domains are more likely to be associated with uptake of osteoporosis prevention recommendations regarding increased calcium intake and physical activity and, to a lesser extent, smoking avoidance.
Background

Published Australian Guidelines for the prevention of osteoporosis across the lifespan include recommendations for adequate dietary calcium intake, weight bearing exercise, limiting alcohol consumption, and smoking avoidance\(^1\). Despite these evidence-based guidelines, uptake of recommendations by the general public remains suboptimal\(^2\)–\(^7\). This is likely to increase the risk of osteoporosis and fragility fracture in later life resulting in adverse consequences for the individual\(^8\) and the healthcare system\(^9\),\(^10\). While this is of concern for the entire population, it is of particular importance in disadvantaged populations who are more likely to have low bone mineral density\(^11\),\(^12\) and an increased risk for fracture\(^13\),\(^14\).

Previous research has been aimed at improving osteoporosis knowledge as a means to improving uptake of prevention behaviours\(^15\)–\(^17\). However higher osteoporosis related knowledge has not translated into higher rates of osteoporosis prevention behaviours\(^16\),\(^18\),\(^19\). It is therefore essential that research is undertaken to explore a broader range of factors which may influence bone health behaviours across the lifespan to better support efforts to increase the uptake of lifestyle prevention guidelines.

Health literacy, defined by the World Health Organization as ‘the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health’\(^20\), may play a role in the ability of individuals to seek out, understand and follow guidelines for osteoporosis prevention. Previous research has identified associations between health literacy and a range of prevention behaviours\(^21\)–\(^25\) and health literacy has been suggested as a possible mediator in health inequalities.
To-date, research regarding health literacy and osteoporosis has largely sought to establish a link between functional health literacy (basic health-related literacy and numeracy skills) and osteoporosis\(^{(26)}\) or musculoskeletal disorders more generally\(^{(27,28)}\). While these studies have reported potential links between specific skills associated with functional health literacy and bone health outcomes, they do little to inform prevention efforts as they fail to explore the broader range of abilities and resources required for management of bone health across the lifespan. A greater understanding of the health literacy strengths and weaknesses of individuals who are not currently adhering to guidelines for osteoporosis prevention may help to inform future efforts to translate osteoporosis prevention guidelines in ways which are accessible and support their uptake in individuals with lower health literacy. Addressing health literacy in this way may also help to reduce inequalities currently seen in bone health.

We aimed to investigate associations between health literacy and the uptake of osteoporosis prevention guidelines related to adequate dietary calcium, limiting alcohol intake, avoiding smoking and undertaking regular weight-bearing physical activity.

**Methods**

Data were collected as part of the 15 year follow-up for women (age range 28-89 years) participating in the Geelong Osteoporosis Study (GOS), with the exception of health literacy data which were collected by mail and electronically from December 2014 until March 2016. Details of the GOS population and non-participation have been published elsewhere\(^{(7,29)}\). In brief, the GOS is a population-based cohort located recruited from the Barwon Statistical Division (BSD), a geographic area in south-eastern Australia. Participants were randomly-selected from electoral rolls using age-stratified sampling techniques: the original cohort was recruited in 1993-97, and an additional group of women aged 20-29 years old were recruited in 2005. The 15-year follow-up of women
was undertaken from December 2010 to October 2014 and included 849 women. Details of non-participation for the 15 year follow-up of women have been provided elsewhere (30). Of the 849 women who participated in the 15-year follow-up, 676 returned full, or at least partial, health literacy data. Reasons for non-participation included; death (n=20), unable to be contacted (n=116), too old (n=12), not interested (n=9), illness (n=8), time restraints (n=4), left the study region (n=1), did not speak English (n=1), invasion of privacy (n=1), or intellectually disabled (n=1).

Dietary calcium and alcohol intake were ascertained from self-reported responses to the Food Frequency Questionnaire(31), and National Health and Medical Research Council (NHMRC) guidelines were used to determine which participants were meeting Recommended Dietary Intakes (RDIs) for calcium (≥1000mg for women aged 19-50 years, and ≥1300mg for women aged ≥ 51 years)(32), and were not exceeding recommended limits of alcohol intake (≤2 standard drinks/day) (33).

Levels of physical activity were determined using age-specific questionnaires that enabled self-reported measures of physical activity to be scored according to three different categories: work/house work, sport and leisure(34,35). Scores for each domain were categorised as <median or ≥median of the study sample.

Highest level of education was self-reported as one of five levels (‘Primary school or less’, ‘High school (not completed)’, ‘High school (completed)’, ‘TAFE/Trade’, or ‘University’): for analyses, the ‘Primary school or less’ and the ‘High school (not completed)’ levels were merged due to low numbers in the former category (n=28).

The residential address of participants were cross-matched with Australian Bureau of Statistics (ABS) census data for 2011, from which the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) was ascertained and used to determine
area-level socioeconomic status (SES). The IRSAD scores identify the level of socioeconomic advantage and disadvantage for areas (encompassing approximately 250 households). Scores are calculated using a number of variables related to social advantage and disadvantage including income, education, employment, occupation, housing, ability to speak English, disability, and access to resources including the internet and cars\(^{36}\). The IRSAD method has previously been used in analyses of the GOS data\(^{37–39}\). IRSAD scores were categorised into quintiles based on the cut-points of the BSD, whereby quintile 1 the most socioeconomically disadvantaged, and quintile 5 was the most socioeconomically advantaged.

Health literacy scores were generated using the Health Literacy Questionnaire (HLQ), a multi-dimensional tool that generates scores across nine domains of health literacy from 44-items (4-6 items per-domain)\(^{40}\). Domains 1-5 were scored using a 4-point Likert scale (Strongly disagree, Disagree, Agree and Strongly agree) while domains 6-9 were scored on a 5-point Likert scale (cannot do, very difficult, quite difficult, easy, and very easy). Health literacy data were collected and managed using the Research Electronic Data Capture (REDCap) tool hosted by Barwon Health\(^{41}\). Analyses were undertaken using SPSS version 22\(^{42}\), Microsoft Excel 2013, and Minitab version 16\(^{43}\).

The expectation maximisation algorithm, as previously employed in HLQ analyses\(^{44}\), was used to impute values for domains where there are no more than two values missing for 4-5 item scales and no more than three values missing from six item scales. Effect sizes (ES) were calculated using Cohen’s d for differences in mean HLQ domain scores between groups who did vs. did not meet recommendations for osteoporosis prevention. As HLQ scores were not normally distributed we undertook analysis of variance (ANOVA) using the Welch method to investigate differences in mean HLQ scores. These methods of determining associations and ES have previously been used in
analyses of HLQ data\textsuperscript{(44,45)}. Binary logistic regression analyses were used to determine the effect of sociodemographic characteristics, including age, education level and SES quintile, on associations between HLQ score and uptake of osteoporosis recommendations.

**Results**

Table 1 presents the sociodemographic characteristics for our study population. A high proportion of women were meeting recommendations regarding smoking and alcohol; however, a smaller proportion met RDIs for dietary calcium. Median scores for physical activity in younger women were higher across all categories than in older women, particularly in the sport category of physical activity where only 20.8% of women aged 60 years and over reported undertaking any physical activity.

Tables 2-4, inclusive, present the ES for mean differences between HLQ scores and osteoporosis prevention behaviours regarding dietary calcium, smoking, alcohol and physical activity. Only one domain, ‘Actively managing health’, showed moderate effect sizes, seen for the ‘sport’ and ‘leisure’ categories of physical activity in women aged <60 years old. All other associations showed only small ES.

In Table 2, higher HLQ scores in domains ‘Having sufficient information’ and ‘Finding health information’ were associated with meeting calcium recommendation. These associations were not changed after adjusting for sociodemographic characteristics. In comparison, individuals with higher scores in those two HLQ domains, in addition to ‘Understanding health information’, were more likely to exceed alcohol intake recommendations. However, associations between higher HLQ score and exceeding alcohol intake recommendations were no longer seen after age-adjustment (Figure 1).
Higher scores in the ‘Actively managing health’ were associated with smoking and results were sustained after adjustment for sociodemographic characteristics.

Tables 3 and 4 present associations and ES between HLQ domains and categories of physical activity for women stratified according to above or below 60 years of age. In women aged <60 years, higher health literacy scores were seen in those women who scored above the median for physical activity in the ‘sport’ and ‘leisure’ categories. In regression analyses, adjusting sociodemographic characteristics did not change associations between health literacy and the ‘sport’ category of physical activity in women aged <60 years, however, associations between the domains ‘Actively managing health’ and ‘Appraisal of health information’ and the ‘leisure’ category of physical activity were no longer seen after adjusting for SES (Figure 2). Smaller changes were seen for associations between domains ‘Finding health information’ (unadjusted OR 1.68, 95%CI 1.08, 2.61) and ‘Understanding health information’ (unadjusted OR 1.69, 95%CI 1.09, 2.64) and the leisure category of physical activity in women <60 years old after adjusting for education level (education adjusted OR 1.48, 95%CI 0.94, 2.33 and OR 1.49, 95%CI 0.94, 2.35 respectively). In women aged ≥60 years, adjusting regression analyses for SES did not change associations between health literacy domains and physical activity categories, however associations between health literacy domains and the ‘household’ category of physical activity were no longer seen after adjusting for age or education level (Figures 3 and 4). A smaller reduction in associations between the domain ‘Finding health information’ and the ‘leisure’ category of physical activity were observed after adjusting for age (unadjusted OR 1.64, 95%CI 1.13, 2.37; age-adjusted OR 1.39, 95%CI 0.94, 2.06).

Discussion
These findings suggest that higher scores in particular aspects of health literacy are associated with uptake of osteoporosis prevention guidelines regarding dietary calcium, smoking avoidance and undertaking specific types of physical activity. Bivariate analysis suggested that exceeding alcohol intake recommendations was associated with higher health literacy scores, however, associations were no longer observed after age adjustment.

Previous research regarding the translation of osteoporosis guidelines for the general public has focused on interventions aimed at increasing osteoporosis prevention behaviours through increasing osteoporosis knowledge (15–17). While most interventions have reportedly increased osteoporosis knowledge (15,17,18,46), greater knowledge has largely failed to influence osteoporosis prevention behaviours (16,18,19). The current study suggests that while health literacy abilities related to health information do play a role in uptake of guidelines, aspects of health literacy beyond having health information are also important for lifestyle prevention of osteoporosis. Of particular interest are domains ‘Appraisal of health information’ and ‘Actively managing my health’, which relate to more complex ‘critical health literacy’ skills (47), were associated with leisure based physical activity in younger women and smoking avoidance. Critical health literacy skills relate to the ability to identify barriers to health behaviours and then use health information to overcome those barriers and gain greater control over health (48).

Therefore, taking health literacy into account, including critical health literacy skills as well as functional health literacy skills, in efforts to translate osteoporosis prevention recommendations may improve their uptake. This applies to both healthcare providers communicating recommendations to patients as well as wider health promotion efforts aimed at improving osteoporosis prevention in the general population.
While increasing knowledge alone may not improve uptake of osteoporosis prevention behaviours (16,18), this study suggests that finding, having, understanding and appraising health information have important roles to play in osteoporosis prevention, particularly meeting dietary calcium and physical activity recommendations. We report comparable findings to those previously reported, in which higher scores for particular aspects of health literacy were associated with physical activity (23,24,49) and diet (21,24,50). However, the majority of previous research used narrow measures of functional health literacy and investigated associations with diet more broadly rather than calcium intake specifically.

We may speculate as to why ‘Navigating the healthcare system’ was associated with physical activity as part of leisure activities for women in both age groups. It may be that barriers to accessing healthcare may prevent women from receiving health advice that encourages them to take up physical activity. Low scores in this domain may also be indicative of a poorer ability to access and navigate services more broadly, which could be a barrier to becoming involved in exercise based leisure activities such as joining a gym or sporting club.

The role of health literacy in physical activity level appears to also depend upon the type of activity measured. Associations between HLQ domains and physical activity for women under 60 were observed only for the ‘sport’ and ‘leisure’ domains of physical activity. Given that the ‘work’ domain of physical activity was not associated with health literacy, we may speculate that an individual’s health literacy might influence the type of leisure activities they participate in, than the type of occupation they hold.

Physical activity associated with housework is similarly less likely to be influenced by health literacy. It is likely that associations seen between health literacy and house work were due to age related disability preventing older individuals in this study (previously shown to have poorer health literacy) from undertaking house work. In our age-adjusted
models, no associations were detected between health literacy and physical activity related to housework. We may have expected a greater number of associations between HLQ domains and the ‘sport’ category of physical activity in women aged 60 years or older, similar to their younger counterparts. However, the small number of women in this age group who reported participating in any sporting activity is likely to have affected our power to detect an association. A larger sample of women over 60 years old is required to further investigate the relationship between health literacy and sport in this age group.

Previous research investigating health literacy and smoking and alcohol consumption has shown mixed results\(^{21,24,51-53}\). For instance, two previous studies have reported no association between health literacy and alcohol intake\(^{24,51}\). However, in accordance with our findings, one previous study reported an inverse relationship between health literacy scores and alcohol consumption\(^{52}\). Unlike our current study, those previous findings were not adjusted for age, thus, it is not possible to determine whether this previous finding may also be driven by age. Previous research report mixed results regarding smoking behaviour, whereby some studies have reported an association with health literacy\(^{21,53}\) whilst others have not\(^{24,51}\). This discordance is likely due to population differences and the heterogeneity between tools used to assess health literacy. The lack of consistency in measurement tools is an issue which has been identified previously as a barrier to comparing results across studies\(^{25}\) with a number of tools found to measure varying aspects of functional health literacy\(^{54,55}\). We suggest that further research using multidimensional measures of health literacy is required to better understand the relationship between health literacy and smoking and alcohol consumption.
Finally, a number of associations between health literacy domains and osteoporosis prevention behaviours reported in the current study were attenuated after adjusting for sociodemographic characteristics including age, education level and SES. Previous studies have suggested that health literacy may be a mediator in health participation and health outcome inequalities \(^{(25,56)}\), thus ensuring osteoporosis guidelines are translated in ways which support individuals with poorer health literacy to access, understand and implement guidelines in their own lives may assist in reducing the socioeconomic differences seen in bone health outcomes \(^{(11–14)}\).

This study has some limitations. Data concerning health behaviours were self-reported and therefore subject to recall bias. Calcium supplementation was not included in measures of dietary intake, and therefore calcium intakes may have been underestimated, however, recent recommendations are to source calcium through the diet where possible \(^{(57)}\). In addition, we did not assess the duration or intensity of physical activity, nor circulating levels of vitamin D. We cannot exclude participation bias related to health literacy; it is likely that this study has not captured individuals with the poorest health literacy who may find study participation too daunting.

**Conclusion**

In this study we report that health literacy regarding accessing and understanding health information, managing health and navigating healthcare systems are likely associated with the uptake of osteoporosis prevention behaviours of adequate dietary calcium intake, avoiding smoking and regular physical activity. Further research using the HLQ tool is required to determine whether similar associations exist in other populations, including adolescents and males.
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Chapter Six


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### Table 1: Participant characteristics (n=676) given as n (%) or median (IQR)

<table>
<thead>
<tr>
<th>Sociodemographic characteristics</th>
<th>n (%) or median (IQR)</th>
<th>missing data n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>59.2 (46.0-92.2)</td>
<td>0</td>
</tr>
<tr>
<td><strong>Education (4 levels)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school (incomplete)</td>
<td>227 (33.6)</td>
<td></td>
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<tr>
<td>High school (complete)</td>
<td>142 (21.1)</td>
<td></td>
</tr>
<tr>
<td>TAFE/Trade</td>
<td>129 (19.1)</td>
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<tr>
<td>University</td>
<td>178 (26.3)</td>
<td></td>
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<tr>
<td><strong>SES Quintiles</strong></td>
<td></td>
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</tr>
<tr>
<td>1 (most disadvantaged)</td>
<td>101 (14.9)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>72 (10.7)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>258 (38.2)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>131 (19.4)</td>
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</tr>
<tr>
<td>5 (most advantaged)</td>
<td>114 (16.9)</td>
<td></td>
</tr>
<tr>
<td><strong>Adequate calcium intake</strong></td>
<td>98 (15.0)</td>
<td>21</td>
</tr>
<tr>
<td><strong>Non-smoker (current)</strong></td>
<td>597 (89.6)</td>
<td>10</td>
</tr>
<tr>
<td>≤2 standard drinks per day</td>
<td>505 (75.7)</td>
<td>11</td>
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<tr>
<td><strong>Physical activity scores</strong></td>
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<tr>
<td>(≤60 years old n=386)</td>
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</tr>
<tr>
<td>Work</td>
<td>2.9 (2.5-3.3)</td>
<td>7</td>
</tr>
<tr>
<td>Sport</td>
<td>2.0 (1.5-2.9)</td>
<td>5</td>
</tr>
<tr>
<td>Leisure</td>
<td>2.5 (2.3-3.0)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Physical activity scores</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(≥60 years old n=286)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household</td>
<td>1.8 (1.6-1.9)</td>
<td>4</td>
</tr>
<tr>
<td>Sport</td>
<td>0.0 (0.0-0.0)</td>
<td>1</td>
</tr>
<tr>
<td>Leisure</td>
<td>0.9 (0.0-4.6)</td>
<td>1</td>
</tr>
</tbody>
</table>

Abbreviations: SES=socioeconomic status
Table 2: Associations between HLQ scores and uptake of lifestyle factors associated with bone health

<table>
<thead>
<tr>
<th>Diet</th>
<th>Calcium</th>
<th>Adequate</th>
<th>Inadequate</th>
<th>Adequate</th>
<th>Inadequate</th>
<th>Adequate</th>
<th>Inadequate</th>
<th>Adequate</th>
<th>Inadequate</th>
<th>Adequate</th>
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<tr>
<td></td>
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<td>Mean score (SD)</td>
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<td>Mean score (SD)</td>
<td>Mean score (SD)</td>
<td>Mean score (SD)</td>
<td>Mean score (SD)</td>
<td>Mean score (SD)</td>
<td>Mean score (SD)</td>
<td>Mean score (SD)</td>
<td>Mean score (SD)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(score range 1-4)</td>
<td>(score range 1-4)</td>
<td>(score range 1-4)</td>
<td>(score range 1-4)</td>
<td>(score range 1-4)</td>
<td>(score range 1-4)</td>
<td>(score range 1-4)</td>
<td>(score range 1-4)</td>
<td>(score range 1-4)</td>
<td>(score range 1-4)</td>
</tr>
<tr>
<td>Dietary Calcium</td>
<td>Adequate</td>
<td>3.21 (0.54)</td>
<td>3.17 (0.39)</td>
<td>3.02 (0.52)</td>
<td>3.13 (0.48)</td>
<td>2.89 (0.41)</td>
<td>4.26 (0.56)</td>
<td>4.11 (0.52)</td>
<td>4.26 (0.48)</td>
<td>4.34 (0.49)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adequate</td>
<td>n=98</td>
<td>n=98</td>
<td>n=98</td>
<td>n=98</td>
<td>n=98</td>
<td>n=97</td>
<td>n=97</td>
<td>n=97</td>
<td>n=97</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inadequate</td>
<td>3.21 (0.50)</td>
<td>3.07 (0.43)</td>
<td>2.99 (0.48)</td>
<td>3.08 (0.49)</td>
<td>2.80 (0.49)</td>
<td>4.17 (0.56)</td>
<td>4.10 (0.57)</td>
<td>4.09 (0.59)</td>
<td>4.27 (0.54)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inadequate</td>
<td>n=556</td>
<td>n=556</td>
<td>n=554</td>
<td>n=555</td>
<td>n=555</td>
<td>n=550</td>
<td>n=549</td>
<td>n=549</td>
<td>n=550</td>
<td></td>
</tr>
<tr>
<td>ES for calcium (95% CI)</td>
<td>Adequate</td>
<td>0.00 (-0.11, 0.04)</td>
<td>0.24 (0.16, 0.27)</td>
<td>0.06 (-0.04, 0.10)</td>
<td>0.10 (0.01, 0.14)</td>
<td>0.19 (0.11, 0.23)</td>
<td>0.16 (0.05, 0.21)</td>
<td>0.02 (-0.09, 0.07)</td>
<td>0.30 (0.20, 0.35)</td>
<td>0.13 (0.03, 0.18)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inadequate</td>
<td>-0.08 (-0.12, 0.00)</td>
<td>-0.19 (-0.22, -0.12)</td>
<td>-0.12 (-0.16, -0.04)</td>
<td>-0.16 (-0.21, -0.09)</td>
<td>-0.08 (-0.12, -0.01)</td>
<td>-0.11 (-0.16, -0.03)</td>
<td>-0.14 (-0.19, -0.06)</td>
<td>-0.19 (-0.24, -0.11)</td>
<td>-0.24 (-0.29, -0.17)</td>
<td></td>
</tr>
</tbody>
</table>

| Standard drinks/day | ≤2 | 3.20 (0.50) | 3.06 (0.43) | 2.97 (0.48) | 3.07 (0.50) | 2.80 (0.49) | 4.17 (0.57) | 4.08 (0.58) | 4.09 (0.60) | 4.25 (0.55) |
|                     | n=504 | n=504 | n=503 | n=503 | n=503 | n=503 | n=498 | n=497 | n=497 | n=498 |
|                     | >2  | 3.24 (0.54) | 3.14 (0.42) | 3.03 (0.53) | 3.15 (0.46) | 2.84 (0.48) | 4.23 (0.51) | 4.16 (0.50) | 4.20 (0.50) | 4.38 (0.47) |
|                     | n=162 | n=160 | n=159 | n=160 | n=160 | n=159 | n=159 | n=159 | n=159 | n=159 |
| ES for alcohol (95% CI) | 0.06 (-0.12, 0.00) | -0.19 (-0.22, -0.12) | -0.12 (-0.16, -0.04) | -0.16 (-0.21, -0.09) | -0.08 (-0.12, -0.01) | -0.11 (-0.16, -0.03) | -0.14 (-0.19, -0.06) | -0.19 (-0.24, -0.11) | -0.24 (-0.29, -0.17) |

| Smoking | No | 3.22 (0.49) | 3.08 (0.43) | 3.00 (0.48) | 3.10 (0.48) | 2.81 (0.49) | 4.17 (0.56) | 4.09 (0.57) | 4.11 (0.58) | 4.27 (0.54) |
|         | n=596 | n=596 | n=594 | n=595 | n=595 | n=595 | n=590 | n=590 | n=589 | n=589 |
| Yes     | 3.12 (0.65) | 3.10 (0.49) | 2.84 (0.56) | 2.99 (0.58) | 2.79 (0.51) | 4.23 (0.66) | 4.17 (0.59) | 4.17 (0.68) | 4.40 (0.52) |
| n=69 | n=69 | n=69 | n=69 | n=69 | n=69 | n=69 | n=69 | n=69 | n=69 |
| ES for smoking (95% CI) | 0.20 (0.16, 0.35) | -0.04 (-0.08, 0.12) | 0.33 (0.29, 0.46) | 0.22 (0.19, 0.36) | 0.04 (0.00, 0.16) | -0.11 (-0.15, 0.05) | -0.14 (-0.19, 0.00) | -0.10 (-0.15, 0.06) | -0.24 (-0.29, -0.12) |

Results in bold indicate a p-value <0.05 for difference in mean scores (between binary groups of lifestyle factor) tested using one-way ANOVA

ES calculated using Cohen’s d. ES are interpreted as “Small” 0.2-0.5, “Moderate” 0.5-0.8, “Large” >0.8
Table 3: Associations (with ES) for HLQ scores and physical activity (binary split) for women aged <60 years

<table>
<thead>
<tr>
<th>Health Literacy Domains</th>
<th>Physical Activity Domain</th>
<th>Mean score (SD) (score range 1-4)</th>
<th>Mean score (SD) (score range 1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feel understood and supported by health care providers</strong></td>
<td>Work ≥median</td>
<td>3.21 (0.53) n=207</td>
<td>4.2 (0.55) n=207</td>
</tr>
<tr>
<td></td>
<td>Work &lt;median</td>
<td>3.17 (0.50) n=172</td>
<td>4.16 (0.53) n=169</td>
</tr>
<tr>
<td></td>
<td>Sport ≥median</td>
<td>3.20 (0.53) n=212</td>
<td>4.20 (0.52) n=209</td>
</tr>
<tr>
<td></td>
<td>Sport &lt;median</td>
<td>3.19 (0.51) n=169</td>
<td>4.18 (0.56) n=168</td>
</tr>
<tr>
<td></td>
<td>Leisur e ≥median</td>
<td>3.22 (0.51) n=238</td>
<td>4.24 (0.52) n=236</td>
</tr>
<tr>
<td></td>
<td>Leisur e &lt;median</td>
<td>3.16 (0.53) n=145</td>
<td>4.11 (0.56) n=143</td>
</tr>
<tr>
<td><strong>Have sufficient information to manage health</strong></td>
<td>Work ≥median</td>
<td>3.14 (0.41) n=207</td>
<td>4.14 (0.53) n=206</td>
</tr>
<tr>
<td></td>
<td>Work &lt;median</td>
<td>3.08 (0.43) n=172</td>
<td>4.10 (0.52) n=169</td>
</tr>
<tr>
<td></td>
<td>Sport ≥median</td>
<td>3.13 (0.44) n=212</td>
<td>4.13 (0.53) n=209</td>
</tr>
<tr>
<td></td>
<td>Sport &lt;median</td>
<td>3.10 (0.41) n=169</td>
<td>4.13 (0.52) n=168</td>
</tr>
<tr>
<td></td>
<td>Leisur e ≥median</td>
<td>3.15 (0.41) n=238</td>
<td>4.26 (0.50) n=236</td>
</tr>
<tr>
<td></td>
<td>Leisur e &lt;median</td>
<td>3.06 (0.44) n=145</td>
<td>4.15 (0.49) n=143</td>
</tr>
<tr>
<td><strong>Actively managing my health</strong></td>
<td>Work ≥median</td>
<td>3.01 (0.54) n=207</td>
<td>2.85 (0.46) n=207</td>
</tr>
<tr>
<td></td>
<td>Work &lt;median</td>
<td>2.95 (0.52) n=172</td>
<td>2.80 (0.51) n=172</td>
</tr>
<tr>
<td></td>
<td>Sport ≥median</td>
<td>3.10 (0.52) n=212</td>
<td>2.86 (0.46) n=212</td>
</tr>
<tr>
<td></td>
<td>Sport &lt;median</td>
<td>3.07 (0.47) n=169</td>
<td>2.78 (0.52) n=169</td>
</tr>
<tr>
<td></td>
<td>Leisur e ≥median</td>
<td>3.08 (0.51) n=238</td>
<td>2.88 (0.48) n=238</td>
</tr>
<tr>
<td></td>
<td>Leisur e &lt;median</td>
<td>3.05 (0.49) n=145</td>
<td>2.72 (0.47) n=145</td>
</tr>
<tr>
<td><strong>Social support for health</strong></td>
<td>Work ≥median</td>
<td>3.08 (0.51) n=207</td>
<td>4.16 (0.53) n=169</td>
</tr>
<tr>
<td></td>
<td>Work &lt;median</td>
<td>3.09 (0.48) n=172</td>
<td>4.10 (0.52) n=169</td>
</tr>
<tr>
<td></td>
<td>Sport ≥median</td>
<td>3.10 (0.52) n=212</td>
<td>4.20 (0.52) n=209</td>
</tr>
<tr>
<td></td>
<td>Sport &lt;median</td>
<td>3.07 (0.47) n=169</td>
<td>4.18 (0.56) n=168</td>
</tr>
<tr>
<td></td>
<td>Leisur e ≥median</td>
<td>3.08 (0.51) n=238</td>
<td>4.24 (0.52) n=236</td>
</tr>
<tr>
<td></td>
<td>Leisur e &lt;median</td>
<td>3.05 (0.49) n=145</td>
<td>4.11 (0.56) n=143</td>
</tr>
<tr>
<td><strong>Appraisal of health information</strong></td>
<td>Work ≥median</td>
<td>2.85 (0.46) n=207</td>
<td>4.14 (0.53) n=206</td>
</tr>
<tr>
<td></td>
<td>Work &lt;median</td>
<td>2.80 (0.51) n=172</td>
<td>4.10 (0.52) n=169</td>
</tr>
<tr>
<td></td>
<td>Sport ≥median</td>
<td>2.86 (0.46) n=212</td>
<td>4.20 (0.52) n=209</td>
</tr>
<tr>
<td></td>
<td>Sport &lt;median</td>
<td>2.78 (0.52) n=169</td>
<td>4.18 (0.56) n=168</td>
</tr>
<tr>
<td></td>
<td>Leisur e ≥median</td>
<td>2.88 (0.48) n=238</td>
<td>4.24 (0.52) n=236</td>
</tr>
<tr>
<td></td>
<td>Leisur e &lt;median</td>
<td>2.72 (0.47) n=145</td>
<td>4.11 (0.56) n=143</td>
</tr>
<tr>
<td><strong>Ability to actively engage with healthcare providers</strong></td>
<td>Work ≥median</td>
<td>4.2 (0.55) n=207</td>
<td>4.24 (0.50) n=206</td>
</tr>
<tr>
<td></td>
<td>Work &lt;median</td>
<td>4.16 (0.53) n=169</td>
<td>4.19 (0.45) n=169</td>
</tr>
<tr>
<td></td>
<td>Sport ≥median</td>
<td>4.20 (0.52) n=209</td>
<td>4.22 (0.48) n=209</td>
</tr>
<tr>
<td></td>
<td>Sport &lt;median</td>
<td>4.18 (0.56) n=168</td>
<td>4.33 (0.46) n=168</td>
</tr>
<tr>
<td></td>
<td>Leisur e ≥median</td>
<td>4.14 (0.53) n=206</td>
<td>4.37 (0.49) n=206</td>
</tr>
<tr>
<td></td>
<td>Leisur e &lt;median</td>
<td>4.10 (0.52) n=169</td>
<td>4.32 (0.46) n=169</td>
</tr>
<tr>
<td><strong>Navigating the healthcare system</strong></td>
<td>Work ≥median</td>
<td>3.01 (0.54) n=207</td>
<td>4.14 (0.53) n=206</td>
</tr>
<tr>
<td></td>
<td>Work &lt;median</td>
<td>2.95 (0.52) n=172</td>
<td>4.10 (0.52) n=169</td>
</tr>
<tr>
<td></td>
<td>Sport ≥median</td>
<td>3.09 (0.48) n=172</td>
<td>4.10 (0.52) n=169</td>
</tr>
<tr>
<td></td>
<td>Sport &lt;median</td>
<td>3.07 (0.47) n=169</td>
<td>4.13 (0.52) n=168</td>
</tr>
<tr>
<td></td>
<td>Leisur e ≥median</td>
<td>3.08 (0.51) n=238</td>
<td>4.24 (0.52) n=236</td>
</tr>
<tr>
<td></td>
<td>Leisur e &lt;median</td>
<td>3.05 (0.49) n=145</td>
<td>4.11 (0.56) n=143</td>
</tr>
<tr>
<td><strong>Ability to find good health information</strong></td>
<td>Work ≥median</td>
<td>2.85 (0.46) n=207</td>
<td>4.24 (0.50) n=206</td>
</tr>
<tr>
<td></td>
<td>Work &lt;median</td>
<td>2.80 (0.51) n=172</td>
<td>4.10 (0.52) n=169</td>
</tr>
<tr>
<td></td>
<td>Sport ≥median</td>
<td>2.86 (0.46) n=212</td>
<td>4.20 (0.52) n=209</td>
</tr>
<tr>
<td></td>
<td>Sport &lt;median</td>
<td>2.78 (0.52) n=169</td>
<td>4.18 (0.56) n=168</td>
</tr>
<tr>
<td></td>
<td>Leisur e ≥median</td>
<td>2.88 (0.48) n=238</td>
<td>4.24 (0.52) n=236</td>
</tr>
<tr>
<td></td>
<td>Leisur e &lt;median</td>
<td>2.72 (0.47) n=145</td>
<td>4.11 (0.56) n=143</td>
</tr>
<tr>
<td><strong>Understand health information</strong></td>
<td>Work ≥median</td>
<td>4.14 (0.53) n=207</td>
<td>4.24 (0.50) n=206</td>
</tr>
<tr>
<td></td>
<td>Work &lt;median</td>
<td>4.10 (0.52) n=169</td>
<td>4.19 (0.45) n=169</td>
</tr>
<tr>
<td></td>
<td>Sport ≥median</td>
<td>4.20 (0.52) n=209</td>
<td>4.22 (0.48) n=209</td>
</tr>
<tr>
<td></td>
<td>Sport &lt;median</td>
<td>4.18 (0.56) n=168</td>
<td>4.33 (0.46) n=168</td>
</tr>
<tr>
<td></td>
<td>Leisur e ≥median</td>
<td>4.14 (0.53) n=206</td>
<td>4.37 (0.49) n=206</td>
</tr>
<tr>
<td></td>
<td>Leisur e &lt;median</td>
<td>4.10 (0.52) n=169</td>
<td>4.32 (0.46) n=169</td>
</tr>
</tbody>
</table>

Results in bold indicate a p-value <0.05 for difference in mean scores (between binary groups of physical activity levels) tested using one-way ANOVA.

ES calculated using Cohen’s d. ES are interpreted as “Small” 0.2-0.5, “Moderate” 0.5-0.8, “Large” >0.8
Table 4: Associations (with ES) for HLQ scores and physical activity (binary split) for women aged ≥60 years

<table>
<thead>
<tr>
<th>Health Literacy Domains</th>
<th>Household</th>
<th>Sport</th>
<th>Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feel understood and supported by health care providers</strong></td>
<td>3.23 (0.54) n=148</td>
<td>3.25 (0.39) n=58</td>
<td>3.25 (0.51) n=148</td>
</tr>
<tr>
<td><strong>Have sufficient information to manage health</strong></td>
<td>3.08 (0.43) n=148</td>
<td>3.09 (0.40) n=58</td>
<td>3.05 (0.41) n=148</td>
</tr>
<tr>
<td><strong>Actively managing my health</strong></td>
<td>3.02 (0.42) n=148</td>
<td>3.09 (0.44) n=57</td>
<td>3.00 (0.43) n=148</td>
</tr>
<tr>
<td><strong>Social support for health</strong></td>
<td>3.08 (0.49) n=148</td>
<td>3.09 (0.44) n=57</td>
<td>3.10 (0.47) n=148</td>
</tr>
<tr>
<td><strong>Appraisal of health information</strong></td>
<td>2.81 (0.48) n=148</td>
<td>2.77 (0.52) n=57</td>
<td>2.83 (0.49) n=148</td>
</tr>
<tr>
<td><strong>Ability to actively engage with health care providers</strong></td>
<td>4.19 (0.58) n=147</td>
<td>4.24 (0.51) n=56</td>
<td>4.21 (0.57) n=145</td>
</tr>
<tr>
<td><strong>Navigating the healthcare system</strong></td>
<td>4.16 (0.53) n=147</td>
<td>4.18 (0.60) n=56</td>
<td>4.17 (0.51) n=145</td>
</tr>
<tr>
<td><strong>Ability to find good health information</strong></td>
<td>4.06 (0.60) n=147</td>
<td>4.04 (0.67) n=56</td>
<td>4.07 (0.56) n=145</td>
</tr>
<tr>
<td><strong>Understand health information</strong></td>
<td>4.26 (0.53) n=147</td>
<td>4.18 (0.57) n=56</td>
<td>4.30 (0.46) n=145</td>
</tr>
</tbody>
</table>

**Mean score (SD)** (score range 1-4)

<table>
<thead>
<tr>
<th>Household</th>
<th>Sport</th>
<th>Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥median</td>
<td>3.24 (0.44) n=134</td>
<td>3.23 (0.52) n=226</td>
</tr>
<tr>
<td>&lt;median</td>
<td>2.98 (0.45) n=133</td>
<td>3.01 (0.46) n=226</td>
</tr>
</tbody>
</table>

**ES for house work (95%CI)**

<table>
<thead>
<tr>
<th>Household</th>
<th>Sport</th>
<th>Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥median</td>
<td>-0.01 (-0.1, 0.06)</td>
<td>0.04 (-0.06, 0.11)</td>
</tr>
<tr>
<td>&lt;median</td>
<td>0.21 (0.14, 0.29)</td>
<td>0.17 (0.10, 0.24)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household</th>
<th>Sport</th>
<th>Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥median</td>
<td>0.32 (0.42) n=132</td>
<td>2.95 (0.42) n=226</td>
</tr>
<tr>
<td>&lt;median</td>
<td>3.09 (0.49) n=134</td>
<td>3.09 (0.49) n=226</td>
</tr>
</tbody>
</table>

**ES for sport (95%CI)**

<table>
<thead>
<tr>
<th>Household</th>
<th>Sport</th>
<th>Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥median</td>
<td>0.21 (0.14, 0.29)</td>
<td>0.17 (0.10, 0.24)</td>
</tr>
<tr>
<td>&lt;median</td>
<td>0.07 (0.00, 0.20)</td>
<td>0.06 (-0.12, 0.05)</td>
</tr>
</tbody>
</table>

**ES for leisure (95%CI)**

<table>
<thead>
<tr>
<th>Household</th>
<th>Sport</th>
<th>Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥median</td>
<td>3.22 (4.07) n=145</td>
<td>3.96 (0.72) n=135</td>
</tr>
<tr>
<td>&lt;median</td>
<td>4.06 (0.60) n=147</td>
<td>3.86 (0.77) n=130</td>
</tr>
</tbody>
</table>

Results in bold indicate a p-value <0.05 for difference in mean scores (between binary groups of physical activity levels) tested using one-way ANOVA.

ES calculated using Cohen’s d. ES are interpreted as “Small” 0.2-0.5, “Moderate” 0.5-0.8, “Large” >0.8.
Figure 1: Age adjusted odds ratios (95% CI) for alcohol intake by HLQ domain
Figure 2: SES adjusted odds ratios (95% CI) for leisure-based physical activity by HLQ domain in women aged <60 years
Figure 3: Age adjusted odds ratios (95%CI) for household physical activity by HLQ domain in women aged ≥60 years
Figure 4: Education-adjusted odds ratios (95%CI) for household physical activity by HLQ domain in women aged ≥60 years
Chapter Seven

Health literacy and agreement between osteoporosis defined by self-report versus bone-mineral density results in older women

(Draft manuscript to be submitted to ‘Journal of Clinical Densitometry’ )
Health literacy and agreement between self-reported and confirmed osteoporosis based upon bone mineral density or combined bone mineral density and fracture criteria in older women

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Abstract (300 word max)

Background
Previous research has reported poor agreement between self-reported osteoporosis and diagnosis based on bone mineral density (BMD) with or without previous fracture. Health literacy is likely to influence this association. We investigated, in older women, associations between health literacy and the agreement between self-reported and confirmed osteoporosis based upon BMD and/or combined BMD and fracture criteria.

Methodology
Women aged ≥50 years participating in the 15yr follow up of the Geelong Osteoporosis Study (GOS) were included in analyses (n=426). BMD was measured by dual-energy x-ray absorptiometry (DXA) and osteoporosis was defined as BMD T-score <-2.5 at the hip and/or spine, or the combination of BMD in the osteopenic range and any adult fracture. Health literacy was ascertained using the Health Literacy Questionnaire (HLQ), a multi-dimensional tool that generates scores across nine independent domains. Using cluster analyses women were divided into four groups, each with distinct health literacy profiles (cluster 1=highest HLQ scores, cluster 4=lowest HLQ scores). Regression analyses were used to investigate associations between health literacy cluster and incorrect self-report of osteoporosis. Differences for mean HLQ scores between participants who correctly vs. incorrectly self-reported osteoporosis were determined for each individual HLQ scale using one-way analysis of variance and Cohen’s D.

Results
Of the 426 participants, 114 (26.8%) incorrectly reported osteoporosis status according to diagnostic criteria. Clusters 4 was significantly more likely to incorrectly self-report osteoporosis than clusters 1 (Odds Ratio: 0.35 [95%CI 0.13, 0.92]).

Women who correctly self-reported osteoporosis status displayed higher mean HLQ scores in Scale 8. ‘Ability to find good health information’ and Scale 9. ‘Understand health information well enough to know what to do’ (ES -0.08 [-0.15, -0.01] and ES -0.08 [-0.17, 0.00], respectively).

Conclusions

Our results suggest that health literacy may play a role in an individual’s ability to correctly self-report their osteoporosis status.

Keywords: health literacy, osteoporosis, self-report
Introduction

Previous research has reported poor agreement between self-reported osteoporosis and a clinical diagnosis based on bone mineral density (BMD) results, with or without previous fracture (1–4). The number of individuals with osteoporosis diagnosed by DXA who correctly self-report their osteoporosis status ranges from 28% (3) to 63% (4). Compared to studies including patients undergoing DXA scans requested by their doctor (1, 4) a lower proportion of correct self-report has been observed in population based studies. (2, 3). Lack of awareness of a diagnosis of osteoporosis may have implications for the uptake of treatment recommendations including lifestyle modification (5, 6) and medication (1) to prevent fracture. While the efficacy of medications to reduce fracture risk is high when adhered to (7–9), adherence for those medications is generally poor (10). This has implications for fracture prevention with significant differences in BMD shown between patients who did and did not adhere to prescribed medications (11).

Although effective public health messages that provide clear recommendations and develop osteoporosis-related knowledge are vital in supporting efforts in osteoporosis prevention, it is equally important to have effective health communication between patient and practitioner. A diagnosis of osteoporosis needs to be accompanied by a clear understanding, from the patient’s perspective, of the disease and strategies for self-management.

Health literacy is defined by the World Health Organization as the ‘cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health’ (12). The Australian Bureau of Statistics (ABS) estimate that 59% of Australians do not possess the health literacy skills required for basic management of health (13). Health literacy is important to a range of health outcomes (14) and management of chronic
health conditions (15), however, there is currently a paucity of research regarding health literacy and osteoporosis.

We have previously suggested the imperative role of health literacy in osteoporosis prevention, specifically lifestyle-related interventions (6) and medication adherence (16). Given the lack of information regarding the importance of health literacy in asymptomatic diseases such as osteoporosis (asymptomatic prior to fracture), we investigated, in older women, associations between health literacy and agreement between self-reported and confirmed osteoporosis based upon BMD and/or combined BMD and fracture criteria.

**Methods**

**Participants**

Health literacy data were collected between 2013-2016 as part of the 15 year follow up of women participating in the ongoing Geelong Osteoporosis Study (GOS), a population based cohort selected randomly from the Barwon Statistical Division in South-Eastern Australia (17). The current analyses included GOS women aged ≥50 years who had sufficient data as osteoporosis becomes more common for women in this age group (18).

**Assessments**

Data, including BMD measured by DXA (Lunar DPX-L), were collected. In keeping with the previous research from Stuart et al (2), we defined osteoporosis as either a BMD T-score < -2.5 at the hip and/or spine (L2-L4, posterior-anterior projection), or the widely used clinical criteria of a combination of BMD in the osteopenic range (T-score -1 to -2.5) plus any fracture occurring after age 20yr.

As part of the ongoing Geelong Osteoporosis Study, participants who underwent DXA received a report which included their BMD T-scores, classification of BMD as
‘Normal’, ‘Osteopenia’ or ‘Osteoporosis’ and brief recommendations for treatment where appropriate. Thus, participants who had a diagnosis of osteoporosis based on BMD T-score alone would have received their diagnosis via report. However, study protocol included encouraging participants to discuss their results with their General Practitioner (GP), with results sent directly to health care professionals at the participant’s request. As commonly used clinical criteria for osteoporosis diagnosis includes BMD T-score in the osteopenic range plus any adult fracture, it is possible that participants with osteopenia plus fracture may have received a diagnosis of osteoporosis from their GP. Therefore, we repeated analyses including women with osteopenia plus fracture as having osteoporosis.

Fracture history for participants was ascertained using radiographically confirmed data from the Geelong Osteoporosis Study Fracture Grid (19), as well as self-reported fractures. To determine self-report of osteoporosis participants were asked to select their past and current medical conditions from a list which included osteoporosis.

Educational attainment was self-reported as one of 5 different categories:

1. Primary school or less
2. High school (not completed)
3. High school (completed)
4. Technical and Further Education (TAFE)/Trade school
5. University

Socioeconomic status (SES) was determined by cross-matching participants’ residential addresses to the ABS 2011 census data, and subsequently to the Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD), using previously published methodology (20). The IRSAD is one of the four indices included in the suite of Socio-Economic Indexes for Areas (SEIFA) and indicates relative socioeconomic
advantage/disadvantage at an area level; a lower quintile indicates greater disadvantage and a higher quintile indicates greater advantage.

Health literacy was measured using the Health Literacy Questionnaire (HLQ), a multidimensional tool that generates scores across nine domains of health literacy (21). Each scale captures a different component of health literacy. The scales are:

1. Feeling understood and supported by healthcare providers;
2. Having sufficient information to manage my health;
3. Actively managing my health;
4. Social support for health;
5. Appraisal of health information;
6. Ability to actively engage with healthcare providers;
7. Navigating the healthcare system;
8. Ability to find good health information;
9. Understand health information well enough to know what to do (21).

Each scale score is made up of responses from between 4 to 6 questionnaire items. Scales 1 to 4 are scored between 1 and 4 and scales 6 to 9 are scored between 1 and 5. Higher scale scores represent a greater self-reported ability, confidence, or degree of support available for that particular aspect of health literacy. The HLQ was self-completed by participants either in hard copy via post or online via electronic survey. Electronic data were collected via the Research Electronic Data Capture (REDCap) tool hosted by Barwon Health (22), which was also used to enter and manage paper HLQ data.

Statistical Analyses

HLQ scale scores were calculated using SPSS version 22 and are reported as means with standard deviations (SD). Missing values for HLQ items were imputed using the
expectation maximisation algorithm as previously undertaken by Beauchamp et al (23).

Participants missing too many items to impute values for one or more scale scores were excluded from cluster analysis but were included for calculations of effect sizes (ES) for those scale scores that could be calculated. Hierarchical cluster analysis using Ward’s method was employed to group women with similar health literacy profiles and multivariate logistic regression analyses were used to assess the relationship between HLQ cluster and correct or incorrect self-report of osteoporosis status.

Cohen’s d Effect Sizes (ES) [95%CI] were calculated for standardised differences in mean HLQ scale scores between participants who correctly vs. incorrectly self-reported osteoporosis. Cohen’s d was calculated as the difference between the two means, divided by the pooled standard deviation (SD) of both means with interpretation of ES as: ‘small’ ES >0.20-0.50, ‘medium’ ES approximately 0.50-0.80, and ‘large’ ES >0.80 (24).

Results

Of the 845 women who returned for the most recent follow-up (median age: 59.5 years, range 29.9 years - 99.5 years) 574 were aged ≥50 years. Of these, 426 (74.2%) had sufficient BMD and HLQ data for inclusion in analyses. In our sample (median age 66 years, IQR 59-74 years), more than half of participants had completed secondary school (55.6%), 39% of participants had sustained an adult fracture and 35 participants (8.2%) were identified as having osteoporosis using BMD results. Table 4 shows health literacy clusters for four different participant profiles of health literacy, with cluster 1 showing the highest HLQ scores while cluster 4 showed the lowest HLQ scores overall. Clusters 1 and 2 contained the highest number of participants (n=201 and 144 respectively) while clusters 3 and 4 had fewer participants (n=39 and 35 respectively).
Osteoporosis defined as osteoporotic BMD only

Of the women identified as having osteoporosis defined by a BMD T-score < -2.5 at the hip and/or spine, 22.9% (n=8) also self-reported osteoporosis. Cluster 4 had the highest proportion of women incorrectly self-reporting (20%), followed by 18% of cluster 3, 9% of cluster 2 and 8% of cluster one (Table 4). In unadjusted models and holding cluster 4 as referent, cluster 1 was significantly less likely to self-report osteoporosis status incorrectly (OR 0.35, 95%CI 0.13, 0.92). Adjusting for age, SES quintile or education level did not change this association (Figure 1).

No significant associations were seen for differences between mean HLQ scale scores for women who did and did not self-report an osteoporosis status that agreed with their BMD results. However a trend (p=0.08) with a small effect size was seen for Scale 1. ‘Feeling understood and supported by healthcare providers’ (Table 5), with individuals who self-reported incorrectly showing higher mean scores for this scale.

Osteoporosis defined as osteoporotic BMD or osteopenia plus any adult fracture

Of the participants self-reporting osteoporosis 69.2% (n=18) did not have a BMD in the osteoporotic range (Table 2). However, half of these women met the alternative criteria, used in clinical settings, of osteopenia of the hip or spine (BMD between 1 and 2.5 SDs below the young adult mean) combined with any adult fracture. Thus, we repeated analyses including women with osteopenia and plus any adult fracture as having osteoporosis.

Using this definition of osteoporosis, 114 participants (26.8%) incorrectly self-reported their osteoporosis status. The majority of participants who incorrectly self-reported (92.1%) met our criteria for osteoporosis but did not self-report. Only n=9 (7.9 %) self-reported osteoporosis but did not meet criteria for osteoporosis (Table 3).
After including women with BMD osteopenia plus any adult fracture in the definition of osteoporosis, clusters 3 and 4 still contained the greatest proportion of women self-reporting incorrectly (35.9% and 42.9% respectively). Clusters 1 and 2 had comparatively fewer women self-reporting incorrectly (25.4% and 20.1% respectively) (Table 4).

After including women with osteopenia plus any adult fracture in the osteoporosis group, both clusters 1 and 2 were significantly less likely to self-report osteoporosis status incorrectly compared to women in cluster 4 (OR 0.45, 95%CI 0.22, 0.95; OR 0.34, 95%CI 0.15, 0.74). Again, adjusting for age, SES or education did not significantly change these associations (Figure 2).

When women with osteopenia plus any adult fracture were included within the osteoporosis group, trends with small effect sizes were seen for three scales; Scale 3. ‘Actively managing health’(p=0.09), Scale 8. ‘Ability to find good health information’(p=0.07) and Scale 9. ‘Understand health information well enough to know what to do’ (p=0.08) (Table 5).

**Discussion**

We report that participants who showed higher health literacy scores were less likely than those with the lowest health literacy scores to incorrectly self-report their osteoporosis status. Trends were observed with small effect sizes for differences between mean scores for health literacy scales related to finding and understanding health information and actively managing health and correct self-report of osteoporosis diagnosis. However when using a BMD only definition of osteoporosis we conversely saw higher scores for Scale 1. ‘Feeling understood and supported by healthcare providers’ in participants who self-reported incorrectly. This trend and small effect size was no longer observed when participants with osteopenia and an adult fracture were
included in the osteoporosis group. As this definition of osteoporosis is commonly used in clinical settings we believe it is possible that participants have received this diagnosis from a healthcare provider with whom they have a good relationship and are thus self-reporting correctly to the best of their knowledge.

Similar to previous studies (1–4), our results suggest that self-reported osteoporosis is likely to be an underestimation of the true prevalence of osteoporosis. However, there is some variation in the literature with participants in studies of patients who had previously undergone DXA scans more likely to self-report correctly (1, 4) than participants of population based studies (2, 3). As current guidelines only recommended DXA scans for individuals at high risk and/or with previous osteoporotic fracture, it is possible that factors, such as perceived fracture risk and referral for DXA scan, may play a role in higher rates of osteoporosis self-report in these groups.

The results of our current study indicate that health literacy may also influence an individual’s ability to correctly identify their osteoporosis status. Should this be the case, the method of providing this information in report form may not be effective in reaching those who face greater health literacy barriers, particularly those who struggle to find and understand health information. Whilst speculative, there may be a number of reasons for this. For instance, it is possible that women with poorer health literacy have difficulty understanding the report provided after their DXA scan or do not read the report due to a lack of time or competing priorities. Previous research has shown that providing information in written form is less effective in improving medication adherence in osteoporosis patients than discussion of DXA results with healthcare professionals (25).

Participants are also encouraged to discuss their BMD results with their regular healthcare provider. However, previous research has shown that osteoporosis has low salience with Australian GPs who considered it a lower priority than other chronic
conditions (26). Time and costs were identified by GPs as the main barriers to investigation of osteoporosis (26). Given this, it may be expected that a large proportion of women with osteoporotic fracture would not recall being informed of their diagnosis. This may possibly contribute to the appearance of significant associations for cluster 2 and trends for two of the 9 scales when women with osteopenia plus any adult fracture were included in the osteoporosis group. This definition is common in clinical settings but not within the GOS BMD reports supplied to participants. Therefore, participants with osteopenia and an adult fracture who do not have a discussion with a healthcare professional about their bone density are unlikely to receive an osteoporosis diagnosis. This has implications for fracture prevention as the greatest number of fractures occur in women with osteopenia (27) and any prior fracture increases the risk of subsequent fracture (28).

Associations were not altered by including age, SES or education in the model. It is possible that restricting the study population to women 50 years and older already accounted for any effect age may have on results, however, ages still ranged from 50.2 to 92.4 years. Education level and SES quintile also showed wide variation (Table 1). Thus, we believe it is possible that understanding of an asymptomatic condition such as osteoporosis may not show preference to any age, SES or education level in contrast to symptomatic diseases such as diabetes or cardiovascular disease which have greater salience with GPs (26) and potentially also the general public.

Strengths and Limitations

This is the first study to investigate associations between health literacy and agreement between self-report of osteoporosis status and BMD diagnosis of osteoporosis. The use of the multidimensional HLQ enabled us to examine a range of health literacy scales. The use of DXA, the gold standard measure of BMD, is also a strength of the study, as
is the radiographically determined fracture data. The population based sample originally selected from the electoral roll is also a strength, however these results may not be generalisable to the entire population as GOS participants are likely to have a higher level of health literacy than similarly aged women in the wider community.

Involvement in the study requires participants to undertake activities, including attending clinical appointments and completing questionnaires, which require at least moderate health literacy abilities. This is likely to discourage those who face the greatest health literacy barriers from participating in the study. GOS participants also undergo DXA scans and receive BMD reports and are therefore more likely than the wider population to be aware of osteoporosis and their own osteoporosis status. Thus, the general population is likely to have many more individuals who struggle with poor health literacy and also a greater number of individuals who are unaware of their osteoporosis status.

The timing of the self-report data is also a limitation of this study. Participants were asked to self-report osteoporosis at the same clinical appointment as the DXA scan which determined BMD. For this reason, participants who had developed osteoporosis since the previous follow up would likely be unaware of their osteoporosis status.

Finally, the study was limited to women and would need to be replicated in men to determine if similar associations exist.

**Conclusion**

Our findings suggest that health literacy, and specifically health literacy skills associated with finding and understanding health information, are potentially important in patient understanding of osteoporosis diagnosis. This has implications for treatment adherence and fracture prevention in populations who face greater health literacy barriers.
Acknowledgements

The Geelong Osteoporosis Study is funded by the National Health and Medical Research Council (Project number 628582).
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workflow process for providing translational research informatics support. J Biomed Inform. 42(2): 377–381


Table 1: Participant characteristics (n=426) Given as n (%) or Median (IQR)

<table>
<thead>
<tr>
<th>Demographic characteristics</th>
<th>n % or median (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>66 (59-74)</td>
</tr>
<tr>
<td>Adult fracture, n (%)</td>
<td>166 (39)</td>
</tr>
<tr>
<td>Osteoporosis medications, n (%)</td>
<td>21 (4.9)</td>
</tr>
<tr>
<td><strong>SES Quintiles (1= most disadvantaged), n (%)</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>73 (17.1)</td>
</tr>
<tr>
<td>2</td>
<td>51 (12.0)</td>
</tr>
<tr>
<td>3</td>
<td>157 (37.0)</td>
</tr>
<tr>
<td>4</td>
<td>76 (17.8)</td>
</tr>
<tr>
<td>5</td>
<td>69 (15.2)</td>
</tr>
<tr>
<td>High school complete, n (%)</td>
<td>237 (55.6)</td>
</tr>
<tr>
<td><strong>Education, n (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Primary school</td>
<td>20 (4.7)</td>
</tr>
<tr>
<td>Secondary education (incomplete)</td>
<td>169 (39.7)</td>
</tr>
<tr>
<td>Secondary education (complete)</td>
<td>93 (21.83)</td>
</tr>
<tr>
<td>TAFE/Trade</td>
<td>68 (16.0)</td>
</tr>
<tr>
<td>University</td>
<td>76 (17.8)</td>
</tr>
<tr>
<td><strong>Health literacy cluster</strong> (cluster 1 = highest health literacy), n (%)&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>201 (48.0)</td>
</tr>
<tr>
<td>2</td>
<td>144 (34.4)</td>
</tr>
<tr>
<td>3</td>
<td>39 (9.3)</td>
</tr>
<tr>
<td>4</td>
<td>35 (8.4)</td>
</tr>
<tr>
<td>BMD Osteoporosis n (%)</td>
<td>35 (8.2)</td>
</tr>
<tr>
<td>BMD Osteoporosis or Osteopenia w. fracture n (%)</td>
<td>122 (28.6)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Missing data; HLQ cluster (n=7)
Table 2: Concordance of self-reported osteoporosis and osteoporosis based upon BMD (T score ≥2.5 SDs below young adult mean)

<table>
<thead>
<tr>
<th>Osteoporosis defined as</th>
<th>No</th>
<th>Yes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMD ≥2.5 SDs below young adult mean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>373 (87.6)</td>
<td>18 (4.2)</td>
<td>391 (91.9)</td>
</tr>
<tr>
<td>Yes</td>
<td>27 (6.3)</td>
<td>8 (1.9)</td>
<td>35 (8.2)</td>
</tr>
<tr>
<td>Total</td>
<td>400 (93.9)</td>
<td>26 (6.1)</td>
<td>426 (100.0)</td>
</tr>
</tbody>
</table>

Table 3: Concordance of self-reported osteoporosis and osteoporosis based upon BMD (T score ≥2.5 SDs below young adult mean) or osteopenia (BMD (T-score -1 to -2.5) and any adult (aged ≥20yr) fracture)

<table>
<thead>
<tr>
<th>Osteoporosis defined as</th>
<th>No</th>
<th>Yes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMD ≥2.5 SDs below young adult mean or BMD (-1 to -2.5) and adult fracture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>295 (69.3)</td>
<td>9 (2.1)</td>
<td>304 (71.4)</td>
</tr>
<tr>
<td>Yes</td>
<td>105 (24.7)</td>
<td>17 (4.0)</td>
<td>122 (28.6)</td>
</tr>
<tr>
<td>Total</td>
<td>400 (93.9)</td>
<td>26 (6.1)</td>
<td>426 (100.0)</td>
</tr>
</tbody>
</table>
Table 4: Mean (SD) HLQ score by cluster across the 9 scales

<table>
<thead>
<tr>
<th>Health Literacy Clusters</th>
<th>NO. of women</th>
<th>N (%) self-reporting osteoporosis status incorrectly (BMD osteoporosis definition)</th>
<th>N (%) self-reporting osteoporosis status incorrectly (BMD osteoporosis and osteopenia plus fracture definition)</th>
<th>Scale 1. Feeling understood and supported by healthcare providers</th>
<th>Scale 2. Having sufficient information to manage my health</th>
<th>Scale 3. Actively managing my health</th>
<th>Scale 4. Social support for health</th>
<th>Scale 5. Appraisal of health information</th>
<th>Scale 6. Ability to actively engage with healthcare providers</th>
<th>Scale 7. Navigating the healthcare system</th>
<th>Scale 8. Ability to find good health information</th>
<th>Scale 9. Understand health information well enough to know what to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Highest health literacy)</td>
<td>201</td>
<td>17 (8.0)</td>
<td>51 (25.4)</td>
<td>3.79 (0.34)</td>
<td>3.70 (0.30)</td>
<td>3.61 (0.37)</td>
<td>3.56 (0.43)</td>
<td>3.43 (0.39)</td>
<td>4.84 (0.25)</td>
<td>4.77 (0.28)</td>
<td>4.86 (0.20)</td>
<td>4.92 (0.16)</td>
</tr>
<tr>
<td>2</td>
<td>144</td>
<td>13 (9.0)</td>
<td>29 (20.1)</td>
<td>3.19 (0.48)</td>
<td>3.10 (0.25)</td>
<td>2.98 (0.38)</td>
<td>3.14 (0.38)</td>
<td>2.84 (0.37)</td>
<td>4.23 (0.42)</td>
<td>4.16 (0.38)</td>
<td>4.16 (0.37)</td>
<td>4.29 (0.41)</td>
</tr>
<tr>
<td>3</td>
<td>39</td>
<td>7 (18.0)</td>
<td>14 (35.9)</td>
<td>2.95 (0.38)</td>
<td>2.73 (0.34)</td>
<td>2.69 (0.44)</td>
<td>2.74 (0.45)</td>
<td>2.43 (0.38)</td>
<td>3.76 (0.47)</td>
<td>3.68 (0.47)</td>
<td>3.68 (0.50)</td>
<td>3.99 (0.44)</td>
</tr>
<tr>
<td>4 (Lowest health literacy)</td>
<td>35</td>
<td>7 (20.0)</td>
<td>15 (42.9)</td>
<td>2.39 (0.66)</td>
<td>1.71 (0.62)</td>
<td>2.34 (0.61)</td>
<td>2.11 (0.70)</td>
<td>2.11 (0.56)</td>
<td>2.09 (0.49)</td>
<td>1.69 (0.48)</td>
<td>1.69 (0.40)</td>
<td>2.06 (0.77)</td>
</tr>
</tbody>
</table>

Highest health literacy  Lowest health literacy
# Chapter Seven

Table 5: Mean Health Literacy Questionnaire scale scores (SD) by self-report of osteoporosis status

<table>
<thead>
<tr>
<th>HLQ scales</th>
<th>BMD Osteoporosis</th>
<th></th>
<th>BMD Osteoporosis or osteopenia plus fracture</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correct self-report n=381</td>
<td>Incorrect self-report n=45</td>
<td>Effect size (95% CI)</td>
<td>Correct self-report n=312</td>
</tr>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Feeling understood and supported by healthcare providers</td>
<td>3.21 (0.52)</td>
<td>3.36 (0.53)</td>
<td>-0.29 (-0.34, -0.13)*</td>
<td>3.22 (0.50)</td>
</tr>
<tr>
<td>Having sufficient information to manage my health</td>
<td>3.06 (0.40)</td>
<td>3.18 (0.49)</td>
<td>-0.29 (-0.33, -0.15)</td>
<td>3.06 (0.37)</td>
</tr>
<tr>
<td>Actively managing my health</td>
<td>2.98 (0.47)</td>
<td>3.11 (0.58)</td>
<td>-0.27 (-0.32, -0.10)</td>
<td>2.96 (0.46)</td>
</tr>
<tr>
<td>Social support for health</td>
<td>3.08 (0.48)</td>
<td>3.11 (0.58)</td>
<td>-0.06 (-0.11, 0.11)</td>
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<td>Appraisal of health information</td>
<td>2.79 (0.49)</td>
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<td>Ability to actively engage with healthcare providers</td>
<td>4.19 (0.53)</td>
<td>4.17 (0.61)</td>
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<td>4.21 (0.51)</td>
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<td>Navigating the healthcare system</td>
<td>4.13 (0.53)</td>
<td>4.08 (0.66)</td>
<td>0.09 (0.04, 0.28)</td>
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<td>Ability to find good health information</td>
<td>4.10 (0.56)</td>
<td>3.95 (0.75)</td>
<td>0.26 (0.20, 0.48)</td>
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<td>Understand health information well enough to know what to do</td>
<td>4.29 (0.50)</td>
<td>4.17 (0.61)</td>
<td>0.21 (0.18, 0.41)</td>
<td>4.31 (0.47)</td>
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*Indicates a trend with a p-value <0.1 for difference in means tested using one-way ANOVA.
Figure 1: Incorrect self-report of osteoporosis (defined as BMD osteoporosis) by HLQ cluster

Cluster 1= Highest HLQ scores, Cluster 4= Lowest HLQ scores

Cluster 4 reference group
**Figure 2:** Odd ratio (95%CI) for Incorrect self-report of osteoporosis (defined as BMD osteoporosis or osteopenia plus fracture) by HLQ cluster

Cluster 1= Highest HLQ scores, Cluster 4= Lowest HLQ scores

Cluster 4 reference group
Chapter Eight

The Role of Health Literacy in the Treatment of Osteoporosis

(Published in the Journal of Bone and Mineral Research 2016)
### AUTHORSHIP STATEMENT

**1. Details of publication and executive author**

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<tbody>
<tr>
<td>Sarah Hosking</td>
<td>School of Medicine</td>
<td><a href="mailto:shoskin@deakin.edu.au">shoskin@deakin.edu.au</a></td>
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**2. Inclusion of publication in a thesis**

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<th>If Yes, please complete Section 3 If No, go straight to Section 4.</th>
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**3. HDR thesis author’s declaration**

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<td>School of Medicine</td>
<td>The role of health literacy in osteoporosis prevention</td>
</tr>
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</table>

Alongside my co-authors I contributed to the initial concept of this letter to the editor and contributed to the drafting and editing of the letter.

I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.

Signature and date: 24/7/2017

**4. Description of all author contributions**

<table>
<thead>
<tr>
<th>Name and affiliation of author</th>
<th>Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rachelle Buchbinder</td>
<td>Contributed to the drafting and editing of the letter</td>
</tr>
<tr>
<td>Julie A Pasco</td>
<td>Contributed to the drafting and editing of the letter</td>
</tr>
<tr>
<td>Lana J Williams</td>
<td>Contributed to the drafting and editing of the letter</td>
</tr>
<tr>
<td>Sharon L Brennan-Olsen</td>
<td>Contributed to the development of the initial concept for this publication as well as drafting and editing of the letter</td>
</tr>
</tbody>
</table>
5. Author Declarations

I agree to be named as one of the authors of this work, and confirm:

vi. that I have met the authorship criteria set out in the Deakin University Research Conduct Policy,

vii. that there are no other authors according to these criteria,

viii. that the description in Section 4 of my contribution(s) to this publication is accurate,

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<td></td>
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<td>Sharon L Brennan</td>
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6. Other contributor declarations

I agree to be named as a non-author contributor to this work.

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<th>Name and affiliation of contributor</th>
<th>Contribution</th>
<th>Signature* and date</th>
</tr>
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</table>

* If an author or contributor is unavailable or otherwise unable to sign the statement of authorship, the Head of Academic Unit may sign on their behalf, noting the reason for their unavailability, provided there is no evidence to suggest that the person would object to being named as author

7. Data storage

The original data for this project are stored in the following locations. (The locations must be within an appropriate institutional setting. If the executive author is a Deakin staff member and data are stored outside Deakin University, permission for this must be given by the Head of Academic Unit within which the executive author is based.)

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This form must be retained by the executive author, within the school or institute in which they are based.
If the publication is to be included as part of an HDR thesis, a copy of this form must be included in the thesis with the publication.
The Role of Health Literacy in the Treatment of Osteoporosis

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To the Editor

We noted with interest the recent Editorial by Khosla and Shane(1) that drew attention to the poor uptake of, and adherence to, therapeutic interventions in patients at risk of fragility fracture. We wish to emphasize the authors’ statement that highlighted the importance of ensuring patients have access to accurate information to inform their healthcare decisions, and we agree that the consequences of osteoporosis and the importance of medication adherence are not necessarily clear to patients. We add that health literacy is likely to play a major role in the ability of patients to access, understand, and apply information in order to make informed decisions about osteoporosis treatment.

To date, very little research has been undertaken regarding health literacy, osteoporosis, and medication adherence. One population-based study found that individuals with osteoporosis had poorer functional health literacy (health-related literacy and numeracy skills) compared with the general population.(2)

Although another study found no association between health literacy and medication adherence in women with osteoporosis,(3) studies of people with other chronic diseases have shown an association between lower levels of functional health literacy and poorer medication adherence.(4)

Functional health literacy tools are limited in their ability to capture the full breadth of the health literacy concept and focus principally on literacy, with some including numeracy skills.(5–7) Additional aspects of health literacy that may be important in the decision to adhere to osteoporosis medication include the doctor–patient relationship as well as the doctor’s ability to impart information and an individual’s ability to understand and appraise additional information on the risks and benefits of treatment well enough to make an informed decision. It is likely that poor medication adherence is multifaceted and complex.

Understanding health literacy needs of individual patients might provide greater insight into the barriers of medication adherence, as discussed by Khosla and Shane. This may be achieved by the application of more recently developed health literacy tools. As an exemplar, the Health Literacy Questionnaire (HLQ)(8) is a multidimensional measure of health literacy that was developed using a grounded approach. The HLQ includes nine independent domains of health literacy, and can be used to identify an individual’s health literacy needs. This information would inform a more person-centered approach to addressing the problem and may be one method for improving medication adherence and patient outcomes.

References


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Chapter Nine

Maternal health literacy and osteoporosis prevention; results from the Vitamin D in Pregnancy study

(Draft manuscript to be submitted to 'Maternal and Child Health Journal')
Maternal health literacy and osteoporosis prevention; results from the Vitamin D in Pregnancy study

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Abstract

Background:

Building and maintain bone health throughout the life course is important to prevent osteoporosis and fracture in later life. Recommendations have been published to promote healthy bone development in childhood, however, adherence to these guidelines is not universal. Previous research suggests that maternal health literacy may play a role in determining child health outcomes, although there is currently a lack of research regarding maternal health literacy and child behaviours which promote bone development.

This study aimed to investigate associations between maternal health literacy and behaviours that promote bone health in mothers and their children.

Methods:

Health literacy data were collected using the Health Literacy Questionnaire (HLQ), for mothers participating in the Vitamin D in Pregnancy (VIP) study, a longitudinal cohort study of mother-child pairs, Maternal demographic and lifestyle information were self-reported. Bone promoting health behaviours in the children were also reported by mothers. Cross-sectional associations between maternal HLQ domains and health behaviours in mothers and their children were investigated using regression analyses, ANOVA and calculation of effect sizes.

Results:

Lower maternal health literacy was not associated with maternal dietary calcium or alcohol intake. However, statistical trends with small effect sizes were observed
between current smoking in mothers and lower maternal health literacy in the domains of ‘Having sufficient information to manage health’, and ‘Actively managing health’. Associations and trends were observed between low maternal health literacy and less time spent outdoors by children particularly for health literacy domains pertaining to accessing, understanding and using health information. We did not detect associations between maternal health literacy and dietary calcium or screen time of children.

Conclusion:

Results from this study suggest that maternal health literacy, particularly the ability to source, understand and use health information, may play a role in determining some behaviours that promote bone health during childhood.

**Keywords:** health literacy, bone health, mother, child
Background

Behaviours that promote bone development throughout childhood are important to the attainment of optimal peak bone mass in early adulthood; thus providing protection against osteoporosis and fracture in later life (Ebeling, Daly, Kerr, & Kimlin, 2011; Janz et al., 2001; Weaver et al., 2016). Recommendations highlight adequate dietary calcium and vitamin D levels, and participation in weight bearing and high-impact physical activity as important in bone development during childhood (Ebeling et al., 2011). However, these recommendations are not universally adhered to (Dror & Allen, 2014; Hills, Bo Andersen, & Byrne, 2011; Jones et al., 1999). Previous research has indicated a relationship between maternal knowledge and maternal and child behaviours that promote bone health (Winzenberg, Hansen, & Jones, 2008; Winzenberg, Oldenburg, Frendin, De Wit, & Jones, 2006).

Maternal knowledge is likely to influence health behaviours of the mother and child, both of which are plausibly influenced by maternal health literacy. Health literacy is defined by the World Health Organization as ‘the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health’ (World Health Organization, 1998). There is a concerning paucity of data pertaining to maternal health literacy and the influence that it may have on the ability of mothers to make health decisions to positively influence the health behaviours of their child. In the field of functional health literacy, a narrow set of health-related literacy and numeracy skills, a small number of studies suggests the importance of maternal functional health literacy in children’s health outcomes. For instance, higher levels of maternal functional health literacy have been positively associated with health influencing behaviours including correct medication dosage and longer duration of breastfeeding, as well as directly
influencing child health outcomes (DeWalt & Hink, 2009; Yin et al., 2009). While functional health literacy plays a role in the broader health literacy of individuals, measuring only functional health literacy fails to capture the wide range of health literacy abilities and resources mothers require in making health-related decisions and supporting health promoting behaviours in their children (Jordan, Osborne, & Buchbinder, 2011).

More recently, multidimensional health literacy tools have been developed to better understand the strengths and weaknesses of individuals and populations across a broad range of health literacy skills and abilities (Batterham, Hawkins, Collins, Buchbinder, & Osborne, 2016). However, there is currently a paucity of studies using multidimensional health literacy tools to understand maternal health literacy and its impact on child health. The use of multidimensional health literacy tools to investigate maternal health literacy and associations with maternal and child bone health behaviours would help inform future interventions to support mothers in making decisions and promoting behaviours in their children.

The current study aims to investigate associations between maternal health literacy and maternal osteoporosis prevention behaviours as well as associations between maternal health literacy and child behaviours which promote bone development.

**Methods**

**Participants**

Data for this study were collected at the 11-year follow-up of the Vitamin D in Pregnancy (VIP) study, a longitudinal study of mothers and their offspring, recruited from south-eastern Australia. Details of baseline recruitment and follow-up during pregnancy and at birth are reported elsewhere (Morley, Carlin, Pasco, & Wark, 2006).
Briefly, mothers were recruited prior to 16 weeks gestation from the Geelong Hospital antenatal clinic between 2002 and 2003, and had returned for follow-up during 2013-2016. Of 402 mother-child pairs enrolled in the VIP study at the birth follow-up, 209 returned for the 11-year follow-up. Of these, 194 (92.8%) mother-child pairs provided health literacy data for the current study.

Data collection

Maternal health literacy was assessed using the multidimensional health literacy measurement tool known as the Health Literacy Questionnaire (HLQ) (Osborne, Batterham, Elsworth, Hawkins, & Buchbinder, 2013). The HLQ is a 44-item questionnaire, which measures health literacy across nine domains:

1. Feeling understood and supported by healthcare providers
2. Having sufficient information to manage my health
3. Actively managing my health
4. Social support for health
5. Appraisal of health information
6. Ability to actively engage with healthcare providers
7. Navigating the healthcare system
8. Ability to find good health information
9. Understand health information enough to know what to do.

Each of these nine domains comprises 4-6 items and measures a specific facet of health literacy, including abilities and resources which contribute to an individual’s capacity to manage their own health. Domains 1-5 are scored on a 4-point scale, while domains 6-9 are scored on a 5-point scale.
Maternal dietary calcium and alcohol intake were estimated via the Cancer Council (Victoria) Food Frequency Questionnaire (Hodge, Patterson, Brown, Ireland, & Giles, 2000). Mothers were categorised as adhering to or exceeding National Health and Medical Research Council (NHMRC) recommendations for alcohol intake not exceeding 2 standard drinks per day (National Health and Medical Research Council, 2016). Maternal dietary calcium intakes were categorised as sufficient or insufficient according to NHMRC guidelines of ≥1000mg for women aged 19-50 years old and ≥1300mg for women aged ≥ 51 years old considered sufficient (National Health and Medical Research Council, 2014). Mothers who self-reported smoking one or more cigarettes per day were categorised as current smokers. Maternal education level was self-reported in five categories; ‘Primary school or less’, ‘High school (not completed)’, ‘High school (completed)’, ‘TAFE/Trade’ or ‘University’. Due to small numbers, the first two categories of educational attainment were collapsed.

Mothers were asked to report the number of serves of five different calcium rich foods their child had consumed in the previous 24 hours. Children were then categorised as either meeting or below the number of serves of calcium rich foods recommended in the Australian Dietary Guidelines with girls aged 9-11 years consuming ≥3 serves/day, boys aged 9-11 years consuming ≥2.5 serves/day and all children 12-13 years consuming ≥3.5 serves/day considered to be meeting recommendations. Time spent outdoors during weekends and school holidays was reported on a three point scale (‘2 hours or less’, ‘More than 2 hours’ or ‘Just about all day’), and used as a proxy for sun exposure. Children with 2 or more hours outdoors were considered to be more likely than children spending less than 2 hours outdoors to achieve adequate levels of vitamin D. Screen time, which has previously shown an inverse relationship with hip bone mineral density (BMD) in children (Janz et al., 2001), was reported as hours per week spent watching television or videos, or playing electronic games, and analysed as average hours/day.
Screen time of ≥2 hours/day was considered as exceeding recommendations (Houghton et al., 2015).

**Analyses**

Analyses of HLQ data followed methods used in previously published research (Beauchamp et al., 2015; Jessup, Osborne, Beauchamp, Bourne, & Buchbinder, 2017). Missing HLQ values were imputed using the expectation maximisation (EM) algorithm in SPSS version 22. This method has been utilised before, in order to calculate HLQ domain scores (Beauchamp et al., 2015). Effect sizes (ES) using Cohen’s d for differences in mean HLQ scores between groups were calculated using Microsoft Excel 2013. All other analyses were undertaken using Minitab version 16. As HLQ scores followed a non-normal distribution, analysis of variance (ANOVA) using the Welch method was used to determine whether differences in mean HLQ scores between groups were significant. Multivariable regression analyses were used to investigate associations between health literacy scores and sociodemographic characteristics.

**Results**

Population characteristics are displayed in Table 1 for mothers (ages 30.3-54.2 years), and their children (ages 10.0-13.4 years). Table 2 displays mean maternal HLQ scores for each of the nine domains. Of the domains scored 1-4, the lowest mean scores were observed for the domains ‘Appraisal of health information’ and ‘Actively managing health’ while the highest mean score was observed for the domain ‘Social support for health’. The domain ‘Navigating the healthcare system’ displayed the lowest mean of the domains scored 1-5, while the highest was observed for the domain ‘Understand health information’.
In multivariable analyses, maternal age was not associated with scores in any domain of the HLQ (data not shown); however, Figure 1 demonstrates that mothers in the highest education category significantly higher scores for HLQ Scale 9. ‘Understand health information well enough to know what to do’.

Table 3 identifies differences in mean HLQ domain scores between mothers who did and did not meet recommendations for dietary calcium, alcohol and smoking. No significant differences were seen between the two groups using one-way ANOVA and regression analyses, however, a trend was observed for differences between mothers who were and were not current smokers for domains ‘Having sufficient information’ (p-value 0.071) and ‘Actively managing health’ (p-value 0.095). Observed trends were also accompanied by small effect sizes for differences in mean HLQ scores between mothers who were smokers compared to non-smokers, with a small ES was also observed for the domain ‘Social support for health’. There were also small effect sizes for differences between mothers who did and did not meet calcium RDIs for the domain ‘Having sufficient information’. In regression analyses, adjusting for maternal age or maternal education level did not significantly alter results.

Table 4 displays mean maternal HLQ scores for mothers of children meeting recommendations for bone development compared to mothers of children who did not meet recommendations. Maternal HLQ was associated with child time spent outdoors for domains ‘Navigating the healthcare system’, ‘Ability to find good health information’ and ‘Understanding health information’ with trends seen for a further two HLQ domains. There were no differences detected in HLQ scores for mothers of children meeting dietary calcium recommendations compared to mothers of children who did not meet recommendations or between mothers of children meeting recommendations regarding screen time compared with mothers of children who
exceeded screen-time limits. In regression analyses, associations were not altered after maternal age and maternal education level were added to the model.

**Discussion**

The findings of this study suggest that maternal health literacy does not appear to be associated with meeting dietary calcium recommendations or alcohol intake in mothers. A trend, and small effect sizes, were observed between lower maternal health literacy and current smoking. Higher maternal HLQ was associated with children’s measures of: increased time regularly spent outdoors, but no associations were observed for screen time or dietary calcium intake. All findings were independent of maternal age and education level. Associations were observed between educational attainment of the mothers and their health literacy for Scale 9. ‘Understand health information well enough to know what to do’.

Previous research has reported positive associations between health literacy and adequate nutrition in adults (Carbone & Zoellner, 2012; Friis, Vind, Simmons, & Maindal, 2016; von Wagner, Knight, Steptoe, & Wardle, 2007) with one study reporting associations between higher scores in the HLQ domains ‘Having sufficient information to manage health’ and ‘Ability to find good health information’ and adequate calcium intake specifically (Hosking et al., 2016). However, the current study did not identify any associations between maternal HLQ scores and their own calcium intake. It may be that women in this study with low calcium intakes experienced barriers unrelated to health literacy which affected their diet. The lack of observed associations between maternal HLQ scores and alcohol intake in our current study are similar to other populations, including Japanese adults (Tokuda, Doba, Butler, & Paasche-Orlow, 2009) and Danish adults with diabetes (Friis et al., 2016). Findings of previous research
regarding health literacy and smoking have been equivocal. Whereas studies from Denmark and Japan have reported no association (Friis et al., 2016; Tokuda et al., 2009), a previous study of women, in the same region as the current study reported an association between smoking behaviour and scores in the HLQ domain ‘Actively managing health’, one of the two domains to show a trend in the current study (Hosking, Pasco, Beauchamp, Buchbinder, & Brennan-Olsen, 2017). These data suggest that the ability to actively manage health may play a role in smoking behaviours of Australian women.

Findings of the current study suggest that maternal health literacy has a limited effect on child behaviours which are recommended to promote healthy bones. Associations between greater time spent outdoors and higher scores for three HLQ domains, as well as trends with small effect sizes observed for two more domains, suggest that maternal health literacy may influence physical activity levels and sun exposure and therefore potentially the children’s vitamin D levels. Furthermore, all but one of the five HLQ domains to display an association or trend for child time spent outdoors measured an ability related to health information. This suggested that health literacy abilities required to find, understand and use health information may be the most important in ensuring a child spends an adequate amount of time outdoors. However, it should be noted that this study did not collect data regarding maternal knowledge of risks associated with sun exposure or use of sun avoidance measures such as sunscreen or covering up with clothing, which may influence outdoor time and sun exposure. Further research is required to better understand the relationship between maternal health literacy and ability to understand and act upon health messages regarding sun exposure that are complex and at times contradictory.
Whilst we did not observe associations between maternal HLQ scores and child calcium intake or screen time, this may be expected, given that as children grow and learn to take make independent decisions, their own health literacy abilities begin to develop (Manganello, 2008). Therefore, it is possible that the children included in this study were of an age at which their own health literacy may play a greater role in shaping their health behaviours.

We acknowledge that this study has strengths and limitations. A major strength is the use of a multidimensional health literacy tool to investigate a range of maternal health literacy abilities in relation to behaviours that influence bone health relevant to both mothers and children. However, small sample sizes may have limited our ability to detect associations between maternal health literacy and all health behaviours explored, particularly between maternal health literacy and smoking behaviours in mother and time spent outdoors by children. Data collected using questionnaires relied on self-report or mother’s report on behalf of the child and are therefore subject to bias. Measures of dietary calcium did not take into account supplementation, however, recent recommendations suggest that, when possible, calcium should be obtained primarily from dietary sources (Osteoporosis Australia, 2017). We used estimates of screen time and time spent outdoors as a surrogate indication of sun exposure and physical activity in children, and acknowledge that direct measures of serum vitamin D levels and physical activity would have been desirable. Finally, this sample was recruited from the pre-natal clinic of one hospital at one time-point and may not be representative of mothers and children living in this region and elsewhere.

Conclusion

Within these constraints, however, results from this study suggest that maternal health literacy may play a role in some health behaviours which influence bone health in both
the mothers and the children. For mothers, their health literacy may play a role in decisions related to smoking but not dietary calcium or alcohol intakes. In older children, maternal health literacy may play a role in the amount of recreational time a child spends outdoors but not with regard to screen time nor dietary calcium.
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https://doi.org/10.1542/peds.2009-1162B

https://doi.org/10.1111/nure.12078


Janz, K. F., Burns, T. L., Torner, J. C., Levy, S. M., Paulos, R., Willing, M. C., &


Chapter Nine


### Table 1: Characteristics of mother-child pairs for the total sample (n=194)

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<tr>
<td>Age</td>
<td>41.5 (4.4)</td>
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</tr>
<tr>
<td>Highest level of education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school incomplete</td>
<td>32 (16.5)</td>
<td></td>
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<tr>
<td>High school complete</td>
<td>31 (16.0)</td>
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</tr>
<tr>
<td>TAFE/Trade</td>
<td>63 (32.5)</td>
<td></td>
</tr>
<tr>
<td>University</td>
<td>68 (35.1)</td>
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<td>≥Calcium recommendations</td>
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<td>≤2 standard drinks/day</td>
<td>111 (58.7)</td>
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</tr>
<tr>
<td>Non-smoker</td>
<td>150 (78.5)</td>
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<td>≥Calcium recommendations</td>
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<td>&gt;2hrs spent outside/day</td>
<td>152 (79.6)</td>
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<tr>
<td>&lt;2hrs screen time/day</td>
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</tr>
</tbody>
</table>
Table 2: Maternal Health Literacy Questionnaire scores (Mean, SD) for total sample n=194

<table>
<thead>
<tr>
<th>Scale</th>
<th>HLQ Scale</th>
<th>Mean (±SD)</th>
<th>Missing data (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Feeling understood and supported by healthcare professionals</td>
<td>3.19 (0.50)</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Having sufficient information to manage my health</td>
<td>3.15 (0.43)</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Actively managing my health</td>
<td>2.95 (0.51)</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Social support for health</td>
<td>3.22 (0.48)</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Appraisal of health information</td>
<td>2.93 (0.49)</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Ability to actively engage with healthcare professionals</td>
<td>4.23 (0.49)</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Navigating the healthcare system</td>
<td>4.17 (0.51)</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Ability to find good health information</td>
<td>4.24 (0.47)</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Understand health information well enough to know what to do</td>
<td>4.33 (0.47)</td>
<td>1</td>
</tr>
</tbody>
</table>

Range 1-4 (lowest - highest)

Range 1–5 (lowest - highest)
Table 3: Mean maternal health literacy scores (SD) and ES (95%CI) across maternal lifestyle risk factors for osteoporosis

<table>
<thead>
<tr>
<th></th>
<th>Feeling understood and supported by healthcare providers</th>
<th>Having sufficient information to manage my health</th>
<th>Actively managing my health</th>
<th>Social support for health</th>
<th>Appraisal of health information</th>
<th>Ability to actively engage with healthcare providers</th>
<th>Navigating the healthcare system</th>
<th>Ability to find good health information</th>
<th>Understanding health information well enough to know what to do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calcium</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;Recommendations</td>
<td>3.18 (0.48)</td>
<td>3.12 (0.43)</td>
<td>2.96 (0.52)</td>
<td>3.21 (0.45)</td>
<td>2.94 (0.46)</td>
<td>4.22 (0.48)</td>
<td>4.16 (0.51)</td>
<td>4.25 (0.47)</td>
<td>4.32 (0.46)</td>
</tr>
<tr>
<td>≥Recommendations</td>
<td>3.22 (0.58)</td>
<td>3.22 (0.45)</td>
<td>2.95 (0.51)</td>
<td>3.22 (0.58)</td>
<td>2.88 (0.59)</td>
<td>4.26 (0.55)</td>
<td>4.21 (0.53)</td>
<td>4.25 (0.50)</td>
<td>4.37 (0.52)</td>
</tr>
<tr>
<td><strong>ES for calcium</strong></td>
<td>0.10 (-0.07, 0.18)</td>
<td>0.24 (0.12, 0.31)</td>
<td>-0.03 (-0.18, 0.05)</td>
<td>0.02 (-0.15, 0.09)</td>
<td>-0.13 (-0.29, -0.05)</td>
<td>0.09 (-0.06, 0.17)</td>
<td>0.09 (-0.06, 0.18)</td>
<td>0.01 (-0.13, 0.09)</td>
<td>0.11 (-0.04, 0.18)</td>
</tr>
<tr>
<td><strong>Alcohol</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;2 drinks/day</td>
<td>3.16 (0.55)</td>
<td>3.13 (0.42)</td>
<td>2.92 (0.52)</td>
<td>3.19 (0.46)</td>
<td>2.89 (0.52)</td>
<td>4.22 (0.54)</td>
<td>4.20 (0.53)</td>
<td>4.28 (0.48)</td>
<td>4.33 (0.48)</td>
</tr>
<tr>
<td>≤2 drinks/day</td>
<td>3.21 (0.47)</td>
<td>3.17 (0.45)</td>
<td>2.98 (0.51)</td>
<td>3.23 (0.50)</td>
<td>2.95 (0.47)</td>
<td>4.24 (0.46)</td>
<td>4.16 (0.51)</td>
<td>4.22 (0.47)</td>
<td>4.34 (0.47)</td>
</tr>
<tr>
<td><strong>ES for time outdoors</strong></td>
<td>0.10 (0.01, 0.22)</td>
<td>0.09 (0.01, 0.18)</td>
<td>0.11 (0.02, 0.23)</td>
<td>0.09 (0.00, 0.19)</td>
<td>0.13 (0.04, 0.25)</td>
<td>0.05 (-0.03, 0.17)</td>
<td>-0.07 (-0.16, 0.05)</td>
<td>-0.12 (-0.12, -0.02)</td>
<td>0.02 (-0.07, 0.13)</td>
</tr>
<tr>
<td><strong>Smoking</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smoker</td>
<td>3.17 (0.51)</td>
<td>3.04 (0.41)*</td>
<td>2.85 (0.44)*</td>
<td>3.14 (0.51)</td>
<td>2.92 (0.48)</td>
<td>4.21 (0.53)</td>
<td>4.11 (0.54)</td>
<td>4.23 (0.43)</td>
<td>4.32 (0.43)</td>
</tr>
<tr>
<td>Non-smoker</td>
<td>3.19 (0.50)</td>
<td>3.18 (0.44)*</td>
<td>2.99 (0.53)*</td>
<td>3.24 (0.47)</td>
<td>2.93 (0.49)</td>
<td>4.24 (0.49)</td>
<td>4.19 (0.51)</td>
<td>4.25 (0.49)</td>
<td>4.33 (0.49)</td>
</tr>
<tr>
<td><strong>ES for screen time</strong></td>
<td>0.04 (-0.04, 0.15)</td>
<td>0.32 (0.25, 0.44)</td>
<td>0.27 (0.19, 0.40)</td>
<td>0.21 (0.13, 0.36)</td>
<td>0.02 (-0.05, 0.17)</td>
<td>0.06 (-0.02, 0.22)</td>
<td>0.15 (0.07, 0.31)</td>
<td>0.04 (-0.04, 0.17)</td>
<td>0.03 (-0.04, 0.17)</td>
</tr>
</tbody>
</table>

Results in bold indicate a p-value <0.05 for difference in means tested using one-way ANOVA.

* Indicates a trend that did not reach significance, p-value <1.0

ES calculated using Cohen’s d. ES are interpreted as “Small” >0.2-0.5, “Moderate” >0.5-0.8, “Large” >0.8.
Table 4: Mean maternal health literacy scores (SD) and ES (95%CI) across maternal lifestyle risk factors for osteoporosis

<table>
<thead>
<tr>
<th></th>
<th>Feeling understood and supported by healthcare providers</th>
<th>Having sufficient information to manage my health</th>
<th>Actively managing my health</th>
<th>Social support for health</th>
<th>Appraisal of health information</th>
<th>Ability to actively engage with healthcare providers</th>
<th>Navigating the healthcare system</th>
<th>Ability to find good health information</th>
<th>Understanding health information well enough to know what to do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean score (SD)</strong></td>
<td><strong>Score range 1-4</strong></td>
<td><strong>Score range 1-5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Calcium</strong>&lt;br&gt;n=160</td>
<td>3.17 (0.57)</td>
<td>3.19 (0.44)</td>
<td>3.01 (0.54)</td>
<td>3.3 (0.48)</td>
<td>2.91 (0.49)</td>
<td>4.21 (0.50)</td>
<td>4.18 (0.49)</td>
<td>4.27 (0.39)</td>
<td>4.35 (0.43)</td>
</tr>
<tr>
<td>≥Recommendation&lt;br&gt;n=131</td>
<td>3.20 (0.47)</td>
<td>3.13 (0.43)</td>
<td>2.93 (0.50)</td>
<td>3.19 (0.48)</td>
<td>2.93 (0.49)</td>
<td>4.24 (0.50)</td>
<td>4.17 (0.53)</td>
<td>4.23 (0.51)</td>
<td>4.32 (0.49)</td>
</tr>
<tr>
<td><strong>ES for calcium (95%CI)</strong></td>
<td>0.06 (-0.02, 0.20)</td>
<td>-0.14 (-0.22, -0.03)</td>
<td>-0.15 (-0.24, -0.02)</td>
<td>-0.13 (-0.21, -0.01)</td>
<td>0.05 (-0.03, 0.17)</td>
<td>0.06 (-0.02, 0.19)</td>
<td>-0.02 (-0.11, 0.10)</td>
<td>-0.08 (-0.17, 0.02)</td>
<td>-0.05 (-0.14, 0.06)</td>
</tr>
<tr>
<td><strong>Time outdoors</strong>&lt;br&gt;n=39</td>
<td>3.11 (0.49)</td>
<td>3.05 (0.38)*</td>
<td>2.86 (0.51)</td>
<td>3.13 (0.39)</td>
<td>2.82 (0.44)*</td>
<td>4.15 (0.43)</td>
<td><strong>4.00 (0.47)</strong></td>
<td><strong>4.10 (0.38)</strong></td>
<td><strong>4.18 (0.40)</strong></td>
</tr>
<tr>
<td>≥2hrs&lt;br&gt;n=152</td>
<td>3.21 (0.51)</td>
<td>3.18 (0.44)*</td>
<td>2.98 (0.51)</td>
<td>3.24 (0.50)</td>
<td>2.96 (0.50)*</td>
<td>4.25 (0.51)</td>
<td><strong>4.22 (0.52)</strong></td>
<td><strong>4.28 (0.49)</strong></td>
<td><strong>4.37 (0.49)</strong></td>
</tr>
<tr>
<td><strong>ES for time outdoors (95%CI)</strong></td>
<td><strong>0.19 (0.11, 0.35)</strong></td>
<td><strong>0.31 (0.24, 0.43)</strong></td>
<td><strong>0.23 (0.15, 0.39)</strong></td>
<td><strong>0.22 (0.15, 0.35)</strong></td>
<td><strong>0.29 (0.21, 0.43)</strong></td>
<td><strong>0.29 (0.12)</strong></td>
<td><strong>0.43 (0.35, 0.58)</strong></td>
<td><strong>0.39 (0.31, 0.51)</strong></td>
<td><strong>0.40 (0.33, 0.53)</strong></td>
</tr>
<tr>
<td><strong>Screen time</strong>&lt;br&gt;n=141</td>
<td>3.19 (0.53)</td>
<td>3.14 (0.47)</td>
<td>2.95 (0.53)</td>
<td>3.22 (0.48)</td>
<td>2.92 (0.50)</td>
<td>4.21 (0.52)</td>
<td>4.14 (0.54)</td>
<td>4.22 (0.48)</td>
<td>4.32 (0.48)</td>
</tr>
<tr>
<td>&lt;2hrs&lt;br&gt;n=48</td>
<td>3.15 (0.42)</td>
<td>3.18 (0.33)</td>
<td>2.99 (0.48)</td>
<td>3.17 (0.48)</td>
<td>2.92 (0.46)</td>
<td>4.28 (0.42)</td>
<td><strong>4.26 (0.44)</strong></td>
<td><strong>4.30 (0.47)</strong></td>
<td><strong>4.36 (0.45)</strong></td>
</tr>
<tr>
<td><strong>ES for screen time (95%CI)</strong></td>
<td><strong>-0.08 (-0.20, 0.00)</strong></td>
<td><strong>0.09 (-0.01, 0.16)</strong></td>
<td><strong>0.08 (-0.05, 0.17)</strong></td>
<td><strong>-0.11 (-0.25, 0.03)</strong></td>
<td><strong>-0.01 (-0.14, 0.08)</strong></td>
<td><strong>0.15 (0.03, 0.23)</strong></td>
<td><strong>0.24 (0.12, 0.33)</strong></td>
<td><strong>0.16 (0.03, 0.24)</strong></td>
<td><strong>0.09 (-0.04, 0.17)</strong></td>
</tr>
</tbody>
</table>

Results in bold indicate a p-value <0.05 for difference in means tested using one-way ANOVA.
* Indicates a trend that did not reach significance, p-value <1.0
ES calculated using Cohen’s d. ES are interpreted as “Small” >0.2-0.5, “Moderate” >0.5-0.8, “Large” >0.8.
Figure 1: Prediction means (95%CI) for education level of mothers across HLQ domains
Chapter Ten: Discussion
Discussion

The overarching objective of this thesis was to investigate the relationship between health literacy and prevention of osteoporosis in women. The results chapters of this thesis have presented, and discussed, the findings of separate analyses in detail; therefore, this discussion will summarise the main findings of each chapter, particularly in context of one another, while also considering the strengths and limitations of this program of research. This discussion will also reflect upon the potential implication of these findings for the prevention of osteoporosis in populations with low health literacy and suggest potential avenues for future research.

In aggregate, findings presented in this thesis suggest that health literacy is important for the uptake of preventive behaviours for osteoporosis. A visual overview of these findings is presented in Figure 10.1. As indicated in Circle 1, results from the Vitamin D in Pregnancy (VIP) study suggest a relationship between low maternal health literacy and less time spent outdoors by children. Similarly, in Circle 3, results from the Geelong Osteoporosis Study (GOS) indicate a relationship between low health literacy and poorer uptake of specific lifestyle recommendations for the prevention of osteoporosis in women aged 28 to 89 years. In older GOS women, lower health literacy scores were associated with a greater likelihood of being unaware of their osteoporosis status (Circle 4), indicating that older women with poorer health literacy are potentially less likely to adequately manage their osteoporosis to prevent a fragility fracture. Collectively, the results of this thesis indicate that poorer health literacy in women is associated with poorer uptake of osteoporosis prevention behaviours across the lifespan and this has the potential for increasing the risk of osteoporosis and fragility fracture in later life.
BIRTH

1. Maternal influence on child bone health
   ↓ Maternal health literacy associated with
   ↓ Child outdoor time

2. Child and adolescent behaviours promoting bone health
   Influence of child/adolescent health literacy currently unknown

3. Lifestyle prevention of osteoporosis in adult women
   ↓ Health literacy associated with
   ↓ Dietary calcium
   ↓ Physical activity
   ↑ Smoking

FRACTURE

4. Awareness of osteoporosis status in older women
   ↓ Health literacy associated with
   ↓ Likelihood of correct self-report of osteoporosis status

5. Management of osteoporosis
   Associations with health literacy currently unknown

6. Age, SES and education level associated with health literacy and bone health across the lifespan

Figure 10.1: Associations between low health literacy and the development of osteoporosis across the lifespan.
Health literacy and social disadvantage

In addition to investigating associations between health literacy and osteoporosis prevention behaviours across the lifespan, this thesis also aimed to investigate associations between health literacy and sociodemographic characteristics.

As outlined in Figure 10.1, Circle 6, associations were observed between health literacy scores and sociodemographic characteristics including age, socioeconomic status (SES) and level of education. Lower education was largely associated with lower health literacy scores in both the GOS population (Chapter Three) and the VIP study population (Chapter Nine) with a small number of domains displaying biphasic associations between health literacy and education. Similarly lower SES was, for the most part, associated with lower health literacy scores in the GOS population (Chapter Three) with biphasic associations seen for a small number of domains.

These findings are of particular significance in the context of osteoporosis prevention as social disadvantage has previously been associated with poorer uptake of osteoporosis related healthcare (1), lower BMD (2–4), and increased likelihood of fracture (5). Previous research has shown that health messages communicated in ways that do not address the needs of disadvantaged populations are likely to result in improved health behaviours in more advantaged groups, increasing health inequities (6). For this reason it is important that public health efforts to improve uptake of osteoporosis prevention messages are designed to be accessible to disadvantaged populations. It has been suggested that the link between social disadvantage and poorer health may in part be attributed to low health literacy (7,8), thus addressing low health literacy in the translation of osteoporosis prevention messages may reduce disparities in bone health outcomes.
Critical health literacy, which refers to abilities required to identify and overcome barriers to health, is likely to be essential in addressing inequities in bone health outcomes. Health literacy domains associated with critical health literacy include; ‘Appraisal of health information’, ‘Actively managing my health’ and ‘Social support for health’ (9). As discussed in the following section, lower scores in two of these domains (‘Actively managing health’ and ‘Appraisal of health information’) were often associated with poorer uptake of osteoporosis prevention recommendations. This may indicate a need to support individuals in appraising osteoporosis prevention information to determine quality and usefulness, and to ensure individuals are motivated and engaged in actively implementing recommendations to manage their own bone health. Addressing these health literacy domains in the delivery of osteoporosis prevention messages and related healthcare may assist in reducing the inequities in bone health outcomes. However, as a range of health literacy skills are generally required to undertake health related tasks, to ensure the greatest impact upon uptake of osteoporosis prevention recommendations interventions must also address low levels of functional and interactive skills in translating prevention messages and delivering related healthcare.

Increasing age was associated with lower health literacy scores in the GOS population (Chapter Three), but not the VIP study population (Chapter Nine). This is likely due to the younger age and narrow age range of women in the VIP study compared to those in the GOS. As osteoporosis and fragility fracture become more common with older age, age disparities in health literacy are an important consideration in the communication between healthcare providers and patients regarding osteoporosis diagnosis and management.

*Domains of health literacy and associations with osteoporosis prevention*
Previous research regarding health literacy and osteoporosis has been limited by the use of tools which measure only functional health literacy. This thesis has expanded upon the existing evidence base in its use of a multidimensional health literacy tool that measures health literacy strengths and weaknesses across multiple domains. This highlights which aspects of health literacy are of greatest importance in the prevention of osteoporosis informing future efforts to improve osteoporosis prevention, particularly for individuals with low health literacy.

The results of this thesis provide evidence that lifestyles for the prevention of osteoporosis are practised by those with higher scores in health literacy domains related to sourcing and understanding health information and self-management of health; of lesser importance were the domains regarding access to healthcare and communication with healthcare providers. This is likely due to the setting in which lifestyle prevention of osteoporosis occurs. For instance, while it is possible that healthcare providers may give advice on maintaining bone health, lifestyle prevention of osteoporosis happens largely in the community rather than within healthcare settings. Thus, an individual’s own abilities to source, understand and use health information to actively manage their health in day-to-day life are likely to have a greater influence on the uptake of prevention recommendations.

While the prevention behaviours investigated were associated with higher HLQ scores in different domains, and results across the two different study population were not consistent, some domains of health literacy were more frequently associated with osteoporosis prevention behaviours than others. Associations and trends were most frequently observed between osteoporosis prevention behaviours and higher scores in health literacy domains regarding health information, including the domains ‘Having sufficient health information’, ‘Ability to find good health information’,
‘Understanding health information’ and to a lesser extent ‘Appraisal of health information’. In GOS women, higher scores in HLQ domains regarding information were associated with adequate dietary calcium intake and leisure-based physical activity, and in older GOS women, were also associated with self-reporting an osteoporosis diagnosis consistent with BMD results. Results from the VIP study indicated that higher maternal HLQ scores in domains regarding finding and understanding health information were associated with increased outdoor time in children. These findings suggest that abilities relating to accessing and understanding health information may be important in supporting the uptake of and adherence to osteoporosis recommendations as well as understanding an osteoporosis diagnosis.

The domain ‘Actively managing health’ displayed significant associations or trends with small effect sizes a number of times throughout this thesis. In particular, smoking was associated with lower scores for the domain ‘Actively managing health’ in GOS women, with a trend observed for the same domain in VIP study mothers. The domain ‘Actively managing health’ was also associated with higher scores for ‘sport’ and ‘leisure’ categories of physical in GOS women under 60 years old. These results indicate that abilities required to manage health in day-to-day life are likely to be important to the uptake of osteoporosis prevention guidelines regarding smoking and physical activity.

Domains relating to accessing healthcare displayed the fewest associations with osteoporosis prevention behaviours across the two studies. The domain ‘Feeling understood and supported by healthcare providers’ and was not associated with any osteoporosis prevention behaviours, while the higher scores for the domain ‘Ability to actively engage with healthcare providers’ were only associated with increased leisure based physical activity in GOS women under 60 years old. The sole domain
related to healthcare that displayed associations with more than one osteoporosis prevention behaviour was the domain ‘Navigating the healthcare system’. Higher scores in this domain were associated with higher scores in the ‘leisure’ category of physical activity for both age groups of GOS women and the ‘household’ category of physical activity in GOS women over 60 years old. An association was also observed for higher maternal HLQ scores in the domain ‘Navigating the healthcare system’ and increased time spent outdoors by the child. It is possible that poorer ability to navigate the healthcare system and actively engage with healthcare providers may prevent women from receiving and understanding the importance of healthcare advice regarding osteoporosis prevention. However, lower scores in this domain may also indicate poorer ability to navigate systems more broadly which could potentially prevent women from becoming involved in physical activity that requires navigating systems such as joining a gym or sporting club.

As lifestyle prevention of osteoporosis occurs largely in the community it could be assumed that the health literacy domain ‘Social support of health’ would be important in supporting the uptake of prevention recommendations. However, throughout this thesis no associations were reported between scores in this domain and osteoporosis prevention behaviours. It is possible that social support has no effect on the uptake of osteoporosis prevention behaviours; however, it is also possible that the lack of associations relate to the HLQ items which make up the domain ‘Social support for health’. Of the five items that make up this domain, three may be interpreted as questions regarding social support in a time of poor health:

- When I feel ill, the people around me really understand what I’m going through
- If I need help, I have plenty of people I can rely on
I have at least one person who can come to medical appointments with me

Only two items refer to social support for health in more broad terms;

- I can get access to several people who understand and support me
- I have strong support from family and friends

Therefore it is possible that the type of social support captured by this domain relates more to support in times of health crisis rather than support for healthy behaviours in day-to-day life.

**Strengths and Limitations**

This thesis has several major strengths. Health literacy was assessed using a multidimensional tool thereby making an important contribution to the evidence-base for an area of inquiry with limited previous research. Data from the GOS were collected from a population-based sample of women, who had been selected at random from electoral rolls and not on the basis of disease. Furthermore, the GOS women and mothers enrolled in the VIP study were drawn from the same geographical region.

There are also some limitations to acknowledge. Data regarding uptake of osteoporosis prevention behaviours including dietary calcium, alcohol intake, physical activity levels and smoking were collected via self-report and are therefore subject to bias. Additionally, not all osteoporosis prevention recommendations were investigated. Adequate Vitamin D levels are also recommended for the prevention of osteoporosis; however, Vitamin D levels of study participants were not measured.

Requirements of participation in a longitudinal study such as being able to complete questionnaires and book and attend clinical appointments, involve some level of
health literacy ability. The GOS and VIP study teams aimed to reduce the burden on participant health literacy by offering the option of completing questionnaires via interview and/or conducting home visits, however, it is still likely that individuals with the lowest levels of health literacy were not recruited or retained in the studies. Therefore, these results may not be representative of the entire population, nor may they be generalisable to other populations.

Finally, it is possible that health literacy might have changed during the short time interval between the 15-year follow-up assessments for GOS women and their responses to the HLQ.

**Implications**

Despite its limitations, these data make a meaningful addition to the evidence-base and take steps toward addressing gaps in the current literature regarding the role of health literacy in the prevention of osteoporosis. It is hoped that these findings will help improve the translation of osteoporosis prevention recommendations for the broader community.

The findings of this thesis indicate that poorer health literacy abilities regarding finding and understanding health information and actively managing health may present barriers to the uptake of lifestyle recommendations for osteoporosis prevention and understanding an osteoporosis diagnosis.

Future efforts to translate osteoporosis prevention messages for the general public need to consider individuals with low health literacy in the design of programs to improve uptake of osteoporosis prevention recommendations (6). Our research suggests that future efforts to improve osteoporosis prevention should place emphasis on understanding how individuals with low health literacy source,
understand and use health information to ensure messages are relayed through channels and in formats likely to be accessed and understood by those at greatest risk. For example, a webpage listing recommendations for osteoporosis prevention is likely to be viewed by individuals competent in sourcing and understanding health information. Reaching individuals who struggle to access and understand health information is likely to require seeking and actively involving at risk groups and presenting information in ways that are easily understood. The public information event evaluated in Chapter Four is an example of this (10). Community groups in disadvantaged neighbourhoods were involved in the development of the information session and in creating a visual tool used to present osteoporosis prevention recommendations for attendees (11). As discussed in Chapter Four, this method of translating osteoporosis recommendations resulted in an increase in knowledge of recommendations among attendees (10).

Similarly, general practitioners and other healthcare providers also need to be aware of the health literacy limitations of their patients when communicating a diagnosis of osteoporosis. Results of this thesis indicate that individuals who struggle to find and understand health information are less likely to correctly identify their osteoporosis status.

**Future directions**

While the results of this thesis contribute significantly toward the previously limited evidence-base regarding health literacy and osteoporosis prevention, there are many avenues for future research.

Early life, including in utero (12–14), infancy and early childhood, is a critical time for bone development (15–17), and mothers play an important role in determining the trajectory of their child’s bone development. While this thesis investigated
associations between maternal health literacy and behaviours that support bone health in older children, further research is required regarding maternal health literacy and offspring bone development during pregnancy, infancy and early life. Similarly, adolescence and early adulthood are also critical periods for bone mineral deposition (18). Therefore, as suggested in Figure 10.1, Circle 2, a greater understanding of associations between adolescent and young adult health literacy and health behaviours which support bone development, would inform efforts to improve uptake of those behaviours.

At the other end of the spectrum, in older individuals who are diagnosed with osteoporosis, preventing fragility fractures through medications to avoid further bone loss and/or promote bone apposition becomes important. Currently, the uptake and adherence to medications for the management of osteoporosis is suboptimal (19). Previous research has reported associations between health literacy and medication adherence in other chronic disease (20); however there is a paucity of data regarding health literacy and adherence to osteoporosis medications (Figure 10.1, Circle 5). Research investigating the associations between health literacy and uptake and adherence to medications in individuals with osteoporosis would help to inform effective communication between healthcare professionals prescribing osteoporosis medications and patients with osteoporosis potentially improving medication uptake and adherence.

In addition, this thesis has investigated associations between health literacy and osteoporosis in women. However, osteoporosis also affects approximately 80,000 men in Australia (21), and 39% of all osteoporotic fractures worldwide occur in men (22). Fractures in men have been associated with reduced psychological and physical quality of life (23) and men are at greater risk of mortality post-hip fracture than
women (24). Thus, osteoporosis prevention in men is an important area of inquiry and analyses for investigating associations between health literacy and osteoporosis prevention in women should be replicated in men to inform osteoporosis prevention efforts across the entire population.

Finally, the data presented within this thesis has highlighted the role health literacy is likely to play in the uptake of osteoporosis prevention behaviours in women. The next step in this pathway is to develop and evaluate strategies to improve uptake of osteoporosis prevention behaviours in women, particularly women with lower health literacy. This process will require the rigorous design and implementation of intervention studies designed to understand and respond to health literacy needs in delivering osteoporosis related information and healthcare. The Ophelia process provides a model for the way robust intervention studies may be designed to respond to health literacy needs for greater health equity (25,26).
Conclusion

In conclusion, this thesis has provided evidence suggesting the important role of health literacy when considering translating lifestyle-specific prevention recommendations for women and children, and in communicating a diagnosis of osteoporosis to older women.

Findings of this thesis indicate that women with lower health literacy are less likely to meet dietary calcium recommendations or participate in physical activity, and are more likely to smoke. Additionally, children of mothers with low health literacy are less likely to spend time outdoors, potentially reducing sun exposure and therefore negatively impacting vitamin D levels that are important in bone development. Older women with lower health literacy were also less likely to be aware of their osteoporosis status, potentially reducing the likelihood of women with low health literacy to access treatment, and therefore limiting their ability to avoid fragility fracture.

Moreover, this thesis has reported that lower health literacy in domains regarding finding, understanding and using health information and actively managing health, are frequently associated with poorer uptake of osteoporosis prevention behaviours. Health literacy domains related to accessing healthcare, communicating with healthcare providers and having adequate social support for health appear to be less significant in the prevention of osteoporosis.

These findings suggest that translation of osteoporosis prevention recommendations needs to occur in ways that are accessible and easily understood by women with low health literacy. Chapter 4 provides one example of a creative and novel approach to
translating osteoporosis prevention messages in a way that is accessible to individuals with poorer health literacy. However, further work is required to develop and evaluate evidence-based, well-designed complex interventions to improve uptake of osteoporosis prevention messages in individuals with low health literacy.

Additionally, healthcare providers need to ensure an osteoporosis diagnosis is communicated in a way that ensures individuals with low health literacy are able to understand.

The findings of this thesis have contributed to the existing evidence-base by to providing data that suggest a relationship between health literacy in women and osteoporosis prevention throughout life; however, further research is required to determine whether similar associations exist in different age groups including adolescent girls and mothers of infants/young children.
References


Appendices
Understanding Health and Healthcare Questionnaire

Thank you for taking the time to complete this questionnaire about health and healthcare.

- There are no right or wrong answers, so please answer every question based on your own experience and thinking about what you do, or might do, if you get sick.
- Completing this questionnaire is voluntary.
- This questionnaire is confidential.

In this questionnaire, please consider **healthcare providers** as doctors and any other allied health professional.

Study ID: ____________________________
Example:

Please indicate how strongly you disagree or agree with the following statements by crossing the response that best describes you now.

Ms. Jane Citizen has answered these questions in the following way:

Check a box by crossing it:

1. I am doing some of my hobbies

2. I have a plan to do some physical activity

Question 1, Jane’s answer shows that right now she agrees that she has been doing some of her hobbies.

Question 2, Jane disagrees with the statement that right now she has a plan to do some physical activity.

Please indicate how strongly you disagree or agree with the following statements by crossing the response that best describes you now.

1. I feel I have good information about health

2. I have at least one healthcare provider who knows me well

3. I can get access to several people who understand and support me

4. I compare health information from different sources

5. When I feel ill, the people around me really understand what I am going through

6. I spend quite a lot of time actively managing my health

7. When I see new information about health, I check up on whether it is true or not
Please indicate how strongly you disagree or agree with the following statements by crossing the response that best describes you now.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>I have at least one healthcare provider I can discuss my health problems with</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>9</td>
<td>I make plans for what I need to do to be healthy</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>10</td>
<td>I have enough information to help me deal with my health problems</td>
<td></td>
<td></td>
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<tr>
<td>11</td>
<td>If I need help, I have plenty of people I can rely on</td>
<td></td>
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<tr>
<td>12</td>
<td>I always compare health information from different sources and decide what is best for me</td>
<td></td>
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<tr>
<td>13</td>
<td>Despite other things in my life, I make time to be healthy</td>
<td></td>
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<tr>
<td>14</td>
<td>I am sure I have all the information I need to manage my health effectively</td>
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<tr>
<td>15</td>
<td>I have at least one person who can come to medical appointments with me</td>
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<td>16</td>
<td>I know how to find out if the health information I receive is right or not</td>
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<tr>
<td>17</td>
<td>I have the healthcare providers I need to help me work out what I need to do</td>
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<tr>
<td>18</td>
<td>I set my own goals about health and fitness</td>
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<tr>
<td>19</td>
<td>I have strong support from family or friends</td>
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<tr>
<td>20</td>
<td>I ask healthcare providers about the quality of the health information I find</td>
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<tr>
<td>21</td>
<td>There are things that I do regularly to make myself more healthy</td>
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<tr>
<td>22</td>
<td>I can rely on at least one healthcare provider</td>
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<tr>
<td>23</td>
<td>I have all the information I need to look after my health</td>
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</tbody>
</table>
Example:

Please indicate how easy or difficult the following tasks are for you to do now.

Ms. Jane Citizen has answered these questions in the following way:

Check a box by crossing it:

<table>
<thead>
<tr>
<th>Task</th>
<th>Cannot do</th>
<th>Very difficult</th>
<th>Quite difficult</th>
<th>Quite easy</th>
<th>Very easy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive a car</td>
<td>☑️</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Read a book</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑️</td>
<td>☑️</td>
</tr>
</tbody>
</table>

Question 1, Jane’s answer shows that right now she cannot drive a car.
Question 2, Jane shows that right now she can read a book quite easily.

Please indicate how easy or difficult the following tasks are for you to do now.

<table>
<thead>
<tr>
<th>Task</th>
<th>Cannot do</th>
<th>Very difficult</th>
<th>Quite difficult</th>
<th>Quite easy</th>
<th>Very easy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find the right health care</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Make sure that healthcare providers understand your problems properly</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Find information about health problems</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Feel able to discuss your health concerns with a healthcare provider</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Confidently fill medical forms in the correct way</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Find health information from several different places</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Have good discussions about your health with doctors</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Get to see the healthcare providers I need to</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Accurately follow the instructions from healthcare providers</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Get information about health so you are up to date with the best information</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Decide which healthcare provider you need to see</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Read and understand written health information</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>Make sure you find the right place to get the health care you need</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<td>☐</td>
</tr>
</tbody>
</table>
Please indicate how easy or difficult the following tasks are for you to do now.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Cannot do</th>
<th>Very difficult</th>
<th>Quite difficult</th>
<th>Quite easy</th>
<th>Very easy</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Get health information in words you understand</td>
<td></td>
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<tr>
<td>15</td>
<td>Discuss things with healthcare providers until you understand all you need to</td>
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<tr>
<td>16</td>
<td>Find out what healthcare services you are entitled to</td>
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<tr>
<td>17</td>
<td>Read and understand all the information on medication labels</td>
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<tr>
<td>18</td>
<td>Get health information by yourself</td>
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<tr>
<td>19</td>
<td>Work out what is the best care for you</td>
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<tr>
<td>20</td>
<td>Ask healthcare providers questions to get the health information you need</td>
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<tr>
<td>21</td>
<td>Understand what healthcare providers are asking you to do</td>
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</tbody>
</table>

**Some details about yourself**

1. Today’s date____/____/20_ _
2. What is your date of birth? ________________________________
3. What is your sex? □ Female □ Male
4. Do you live alone? □ Yes □ No
5. In which country were you born? ____________________________
6. What is your home postcode? _______________________________
7. Are you an Aboriginal or Torres Strait Islander? □ Yes □ No
8. Do you speak English at home? □ Yes □ No
9. What is the highest level of education you have attended? (Tick one only)

☐ Primary school or less
☐ High school (not completed)
☐ High school (completed)
☐ TAFE/Trade
☐ University

10. Do you have a long standing illness or disability? Please tick all that apply

☐ Arthritis
☐ Back pain
☐ Heart problems
☐ Asthma
☐ Cancer
☐ Depression or anxiety
☐ Diabetes
☐ Stroke
☐ Other, please specify__________________________________________
☐ None of the above

11. Do you have private health insurance? ☐ Yes ☐ No

12. Do you have a health care card? ☐ Yes ☐ No

Did someone help you complete this questionnaire? ☐ Yes ☐ No
If yes, please describe in what way you were helped: __________________________

Thank you for your time
Dietary Questionnaire

QUESTIONS ABOUT WHAT YOU USUALLY EAT AND DRINK

INSTRUCTIONS:
This questionnaire is about your usual eating habits over the past 12 months. Where possible give only one answer per question for the type of food you eat most often. (If you can't decide which type you have most often, answer for the types you usually eat.)
- Use a soft pencil only, preferably 2B.
- Do not use any biro or felt tip pen.
- Erase mistakes fully.
- Make no stray marks.

Please MARK LIKE THIS:

1. How many pieces of fresh fruit do you usually eat per day? (Count 1/2
   cup of diced fruit, berries or grapes as one piece.)
   - I didn't eat fruit
   - less than 1 piece of fruit per day
   - 1 piece of fruit per day
   - 2 pieces of fruit per day
   - 3 pieces of fruit per day
   - 4 or more pieces of fruit per day

2. How many different vegetables do you usually eat per day? (Count all
   types, fresh, frozen or tinned.)
   - less than 1 vegetable per day
   - 1 vegetable per day
   - 2 vegetables per day
   - 3 vegetables per day
   - 4 vegetables per day
   - 5 vegetables per day
   - 6 or more vegetables per day

3. What type of milk do you usually use?
   - none
   - full cream milk
   - reduced fat milk
   - skim milk
   - soya milk

4. How much milk do you usually use per day? (Include flavoured milk and
   milk added to tea, coffee, cereal, etc.)
   - none
   - less than 250 ml (1 large cup or mug)
   - between 250 and 500 ml (1-2 cups)
   - between 500 and 750 ml (2-3 cups)
   - 750 ml (3 cups) or more

5. What type of bread do you usually eat?
   - I don't eat bread
   - high fibre white bread
   - white bread
   - wholemeal bread
   - rye bread
   - multi-grain bread

6. How many slices of bread do you usually eat per day? (Include all types, fresh or toasted and count one bread roll as 2 slices.)
   - less than 1 slice per day
   - 1 slice per day
   - 2 slices per day
   - 3 slices per day
   - 4 slices per day
   - 5-7 slices per day
   - 8 or more slices per day

7. Which spread do you usually put on bread?
   - I don't usually use any fat spread
   - margarine of any kind
   - polyunsaturated margarine
   - monounsaturated margarine
   - butter and margarine blends
   - butter

8. On average, how many teaspoons of sugar do you usually use per day? (Include sugar taken with tea and coffee and on breakfast cereal, etc.)
   - none
   - 1 to 4 teaspoons per day
   - 5 to 8 teaspoons per day
   - 9 to 12 teaspoons per day
   - more than 12 teaspoons per day

9. On average, how many eggs do you usually eat per week?
   - I don't eat eggs
   - less than 1 egg per week
   - 1 to 2 eggs per week
   - 3 to 5 eggs per week
   - 6 or more eggs per week

10. What types of cheese do you usually eat?
   - I don't eat cheese
   - hard cheeses, e.g. parmesan, ro mano
   - firm cheeses, e.g. cheddar, edam
   - soft cheeses, e.g. camembert, brie
   - ricotta or cottage cheese
   - cream cheese
   - low fat cheese

DO NOT WRITE IN THIS AREA.
For each food shown on this page, indicate how much on average you would usually have eaten at main meals during the past 12 months. When answering each question, think of the amount of that food you usually ate, even though you may rarely have eaten the food on its own.

If you usually ate more than one helping, fill in the oval for the serving size closest to the total amount you ate.

11. When you ate potato, did you usually eat:
   - I never ate potato
   - Less than A
   - A
   - Between A & B
   - B
   - Between B & C
   - C
   - More than C

12. When you ate vegetables, did you usually eat:
   - I never ate vegetables
   - Less than A
   - A
   - Between A & B
   - B
   - Between B & C
   - C
   - More than C

13. When you ate steak, did you usually eat:
   - I never ate steak
   - Less than A
   - A
   - Between A & B
   - B
   - Between B & C
   - C
   - More than C

14. When you ate meat or vegetable casserole, did you usually eat:
   - I never ate casserole
   - Less than A
   - A
   - Between A & B
   - B
   - Between B & C
   - C
   - More than C
### Times You Have Eaten

<table>
<thead>
<tr>
<th>CEREAL FOODS, SWEETS &amp; SNACKS</th>
<th>NEVER per month</th>
<th>less than once per week</th>
<th>1 to 3 times per day</th>
<th>1 time</th>
<th>2 times</th>
<th>3 to 4 times</th>
<th>5 to 6 times</th>
<th>1 time</th>
<th>2 times</th>
<th>3 or more times</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Bran™</td>
<td></td>
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<tr>
<td>Sultana Bran™, FibrePlus™, Branflakes™</td>
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<td>Weet Bix™, Vita Brit™, Weeties™</td>
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<tr>
<td>Cornflakes, Nutrigrain™, Special K™</td>
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<td>Porridge</td>
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<td>Muesli</td>
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<td>Rice</td>
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<td>Pasta or noodles (include lasagne)</td>
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<tr>
<td>Crackers, crispbreads, dry biscuits</td>
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<tr>
<td>Sweet biscuits</td>
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<tr>
<td>Cakes, sweet pies, tarts and other sweet pastries</td>
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<tr>
<td>Meat pies, pasties, quiche and other savoury pastries</td>
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<tr>
<td>Pizza</td>
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<tr>
<td>Hamburger with a bun</td>
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<td>Chocolate</td>
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<tr>
<td>Flavoured milk drink (cocoa, Milo™, etc.)</td>
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<tr>
<td>Nuts</td>
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<tr>
<td>Peanut butter or peanut paste</td>
<td></td>
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<td>Corn chips, potato crisps, Twisties™, etc.</td>
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<td>Jam, marmalade, honey or syrups</td>
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<td>Vegemite™, Marmite™ or Promite™</td>
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<table>
<thead>
<tr>
<th>DAIRY PRODUCTS, MEAT &amp; FISH</th>
<th>NEVER per month</th>
<th>less than once per week</th>
<th>1 to 3 times per day</th>
<th>1 time</th>
<th>2 times</th>
<th>3 to 4 times</th>
<th>5 to 6 times</th>
<th>1 time</th>
<th>2 times</th>
<th>3 or more times</th>
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<td>Cheese</td>
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<td>Beef</td>
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<td>Corned beef, luncheon meats or salami</td>
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<td>Sausages or frankfurters</td>
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<td>Fish, steamed, grilled or baked</td>
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<td>Fish, fried (include take-away)</td>
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<tr>
<td>Fish, tinned (salmon, tuna, sardines, etc.)</td>
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<table>
<thead>
<tr>
<th>FRUIT</th>
<th>NEVER per month</th>
<th>less than once per week</th>
<th>1 to 3 times per day</th>
<th>1 time</th>
<th>2 times</th>
<th>3 to 4 times</th>
<th>5 to 6 times</th>
<th>1 time</th>
<th>2 times</th>
<th>3 or more times</th>
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<tbody>
<tr>
<td>Tinned or frozen fruit (any kind)</td>
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<td>Fruit juice</td>
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<td>Oranges or other citrus fruit</td>
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<td>Bananas</td>
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<tr>
<td>Watermelon, rockmelon (cantaloupe), honeydew, etc.</td>
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<td>Pineapple</td>
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<td>Strawberries</td>
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<td>Apricots</td>
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<tr>
<td>Peaches or nectarines</td>
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<tr>
<td>Mango or paw paw</td>
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<td>Avocado</td>
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</table>
### Vegetables (including fresh, frozen and tinned)

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>NEVER</th>
<th>&lt; 1 time/month</th>
<th>1 time/month</th>
<th>2 times/week</th>
<th>3 to 5 times/week</th>
<th>6 to 9 times/week</th>
<th>10 to 12 times/week</th>
<th>13 or more times/week</th>
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</thead>
<tbody>
<tr>
<td>Potatoes, roasted or fried</td>
<td>D1</td>
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<tr>
<td>Potatoes cooked without fat</td>
<td>D2</td>
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<tr>
<td>Tomato sauce, tomato paste or dried tomatoes</td>
<td>D3</td>
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<tr>
<td>Fresh or tinned tomatoes</td>
<td>D4</td>
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<tr>
<td>Peppers (capsicum)</td>
<td>D5</td>
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<tr>
<td>Lettuce, endive, or other salad greens</td>
<td>D6</td>
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<tr>
<td>Cucumber</td>
<td>D7</td>
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<td>Celery</td>
<td>D8</td>
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<tr>
<td>Beetroot</td>
<td>D9</td>
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<tr>
<td>Carrots</td>
<td>D10</td>
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<tr>
<td>Cabbage or Brussels sprouts</td>
<td>D11</td>
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<tr>
<td>Cauliflower</td>
<td>D12</td>
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<tr>
<td>Broccoli</td>
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<td>Silverbeet or spinach</td>
<td>D14</td>
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<tr>
<td>Peas</td>
<td>D15</td>
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<tr>
<td>Green beans</td>
<td>D16</td>
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<tr>
<td>Bean sprouts or alfalfa sprouts</td>
<td>D17</td>
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<tr>
<td>Baked beans</td>
<td>D18</td>
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<tr>
<td>Soy beans, soy bean curd or tofu</td>
<td>D19</td>
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<tr>
<td>Other beans (include chick peas, lentils, etc.)</td>
<td>D20</td>
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<tr>
<td>Pumpkin</td>
<td>D21</td>
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<tr>
<td>Onion or leeks</td>
<td>D22</td>
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<tr>
<td>Garlic (not garlic tablets)</td>
<td>D23</td>
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<tr>
<td>Mushrooms</td>
<td>D24</td>
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<tr>
<td>Zucchini</td>
<td>D25</td>
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</tbody>
</table>

### 16. Over the last 12 months, how often did you drink beer, wine and/or spirits?

#### Times That You Drank

<table>
<thead>
<tr>
<th>Drink</th>
<th>NEVER</th>
<th>&lt; 1 time/month</th>
<th>1-3 days/month</th>
<th>1 day per week</th>
<th>2 days per week</th>
<th>3 days per week</th>
<th>4 days per week</th>
<th>5 days per week</th>
<th>6 days per week</th>
<th>Every day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beer (low alcohol)</td>
<td>1</td>
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<tr>
<td>Beer (full strength)</td>
<td>2</td>
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<tr>
<td>Red wine</td>
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<td>White wine (include sparkling wines)</td>
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<tr>
<td>Fortified wines, port, sherry, etc.</td>
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<tr>
<td>Spirits, liqueurs, etc.</td>
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</table>

When answering the next two questions, please convert the amounts you drank into glasses using the examples given below. For spirits, liqueurs, and mixed drinks containing spirits, please count each nip (30 ml) as one glass.

- 1 can or stubby of beer = 2 glasses
- 1 bottle wine (750 ml) = 6 glasses
- 1 large bottle beer (750 ml) = 4 glasses
- 1 bottle of port or sherry (750 ml) = 12 glasses

### 17. Over the last 12 months, on days when you were drinking, how many glasses of beer, wine and/or spirits altogether did you usually drink?

#### Total Number of Glasses Per Day

<table>
<thead>
<tr>
<th>Glasses Per Day</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10 or More</th>
</tr>
</thead>
</table>

### 18. Over the last 12 months, what was the maximum number of glasses of beer, wine and/or spirits that you drank in 24 hours?

#### Maximum Number of Glasses Per 24 Hours

<table>
<thead>
<tr>
<th>Glasses Per Day</th>
<th>1-2</th>
<th>3-4</th>
<th>5-6</th>
<th>7-8</th>
<th>9-10</th>
<th>11-12</th>
<th>13-14</th>
<th>15-16</th>
<th>17-18</th>
<th>19 or More</th>
</tr>
</thead>
</table>

© Copyright The Cancer Council Victoria 2005. Thank You for completing this questionnaire.
Participant Information and Consent Form

**Full Project Title:** 92/01 The epidemiology of osteoporosis in Australia: a population-based study in Geelong. (Kotowicz MA) and 00/56 Male Osteoporosis: A population-based study in Geelong (Pasco JA).

**Extension study:** 92/01_E7 and 00/56_E2: Geelong Osteoporosis Study: a prospective study beyond twenty years.

**Principal Researchers:**
Julie A Pasco, Geoff C Nicholson, Mark A Kotowicz, Michael Berk

1. **Introduction**

You are invited to take part in this research project, which is a sub-section of the Geelong Osteoporosis Study, for which you have previously consented.

This Participant Information and Consent Form contains detailed information about this follow-up component of the Geelong Osteoporosis Study research project. Its purpose is to explain to you as openly and clearly as possible all the procedures involved in this project before you decide whether or not to take part in it.

Please read this Participant Information and Consent Form carefully. Feel free to ask questions about any information in the form.

Once you understand what the project is about and if you agree to take part in it, you will be asked to sign the Consent Form. By signing the Consent Form you indicate that you understand the information and that you give your consent to participate in the research project. You will be given a copy of the Participant Information and Consent Form to keep as a record.

2. **What is the purpose of this research project?**

This study is designed to provide information about osteoporosis and other disorders. The aims of the study are to determine:

- risk factors for low bone mass, fracture and other disorders such as obesity, diabetes and cardiovascular disease
- bone quality and bone mass using ultrasound (sound wave) measurements of the heel
- body composition using bone densitometry, measures of body dimensions and skinfold thickness
- associations between mental health, well-being variables and physical disorders such as osteoporosis.

Approximately 2800 men and women will participate in this phase of the project.
3. **What does participation in this research project involve?**

Your participation in this project will involve completion of questionnaires, an interview and physical measurements as follows:

- questionnaires will seek information concerning risk factors for the development of osteoporosis and other disorders. There will be comprehensive questions concerning your physical and mental health, well-being, medication history, diet, falls, fractures, exercise patterns and lifestyles. As it may be necessary to confirm your self-reported medication use, health services utilisation and medical history, we will also seek your permission to access your medical records and Medicare records; you may withhold consent for this, if you wish.

- you will also be asked a series of questions relating to aspects of your feelings, thoughts and behaviour. Disorders such as depression have a severe impact on a significant proportion of the population. An increased understanding of these disorders is essential in order that preventions and treatments may be developed.

- a clinical assessment will include measurement of your blood pressure, height, weight and waist and hip circumferences.

- a scan which measures your bone mass in the spine, hip, forearm and total body to measure the calcium content of your bones, and the amount of fat and lean tissue in your body, using a dual energy x-ray densitometer. The painless procedure takes approximately half an hour while you are lying on an x-ray table.

- an ultrasound measurement at the heel. During this procedure you will be required to place your foot in the ultrasound machine for a few minutes.

- a handgrip test that will assess your strength. It is measured with a manual grip tester, requiring you to apply pressure to close a hand-held meter with your hand.

- measurement of skinfold thickness ('pinch test') with callipers for assessing body fat.

Providing ongoing funding is available, we plan to recall you for assessment at five-yearly intervals. Data from this study may be used as reference data to identify risk factors for other diseases. Parts of this study may also be used for the purposes of obtaining an academic qualification. In the event that we establish collaborations (partnerships) with other researchers and/or commercial partners, your information and samples may be used for further research into metabolic and psychiatric disorders. For such partnerships to work, it is important that you assign ownership of all the information to the Geelong Osteoporosis Study research team. You may withhold consent for your information to be used by collaborators if you wish.

4. **What are the possible benefits?**

We cannot guarantee or promise that you will receive any benefits from this project but the information from the study may benefit people in the future.

5. **What are the possible risks?**

This research study involves exposure to a very small amount of radiation from the DEXA scans, that you would not normally receive. As part of everyday living, everyone is exposed to naturally occurring background radiation and receives a dose of about 2 millisieverts (mSv) each year. The effective dose you will receive from all the x-rays in this study will be approximately 0.042 mSv. At this dose level, no harmful effects of radiation have been demonstrated as any effect is too small to measure. The risk is believed to be minimal.

The ultrasound measurement is a rapid, painless procedure, not involving x-rays.
6. **Do I have to take part in this research project?**

Participation in this research project is voluntary. If you do not wish to take part, you do not have to. If you decide to take part and later change your mind, you are free to withdraw from the project at a later stage. If you decide to leave the project, the researchers would like to keep the personal and/or health information about you that has been collected. This is to help them make sure that the results of the research are accurate. Similarly, if you provide a body scan as part of this project, the researchers would like to retain this. However, if you do not wish for your information to be retained, you must tell a researcher before you withdraw from the project. Your decision whether to take part or not, or to take part and then withdraw, will not affect your routine treatment, your relationship with those treating you or your relationship with Barwon Health (The Geelong Hospital) or Deakin University.

Before deciding whether or not to take part, you may wish to discuss the project with a relative or friend or your local health worker. Similarly, before you make your decision, a member of the research team will be available so that you can ask any questions you have about the research project. Once you feel confident that you have all the required information, you may then sign the Consent Form.

7. **How will I be informed of the final results of this research project?**

Periodically you will be sent newsletters summarising research findings and informing you of the progress of the project. Bone mineral density results will be routinely sent to you and your doctor if you request it.

8. **What will happen to information about me?**

Any information obtained in connection with this research project that can identify you will remain confidential and will only be used for the purpose of this research project. Use of any information obtained in connection with this research project for future studies can only be used upon further approval from the Human Research Ethics Committee. The information will be retained for a minimum of 7 years after the completion of the study, in accordance with the Australian Code for the Responsible Conduct of Research. After this period, all hard copies of data will be shredded and destroyed, and all data files will be permanently deleted.

Data will be de-identified prior to data analysis thereby preserving the privacy of all participants. Data will be collated into group findings for publication.

The information will be stored in an archive room based at Barwon Health. This is a secure facility with limited access to staff members. Electronic data will be stored in databases password protected and accessible only to research staff.

9. **Can I access research information kept about me?**

In accordance with relevant Australian and/or Victorian privacy and other relevant laws, you have the right to access the information collected and stored by the researchers about you. Please contact one of the researchers named at the end of this document if you would like to access your information.

In addition, in accordance with regulatory guidelines, the information collected in this research project will be kept for a minimum of 7 years. Access to information about you after this point will not be possible.

10. **Is this research project approved?**

This study has been approved by the Human Research Ethics Committee, Barwon Health. This project will be carried out according to the National Statement on Ethical Conduct in Human Research (2007) produced by the National Health and Medical Research Council.
of Australia. This statement has been developed to protect the interests of people who agree to participate in human research studies.

**11. Whom can I contact?**

If you want any further information concerning this project, please contact the Principal Investigator, Professor Julie Pasco on (03) 42153331 or the research centre on (03) 42153333.

If you have any complaints about any aspect of this project, please contact Bernice Davies, RGO/HREC Barwon Health Research Office, (03) 42153372 or The Manager, Office of Research Integrity, Deakin University, (03) 92517129.
CONSENT FORM

92/01 E7 and 00/56_E2: Geelong Osteoporosis Study: Fracture risk prediction based on twenty years of prospective data.

Principal Researcher(s):

*Julie A Pasco, Geoff C Nicholson, Mark A Kotowicz, Michael Berk*

I have read, or have had read to me in my first language, and I understand the Participant Information and Informed Consent Form Version 1E, Date: 23 Aug 2013.

The researcher has agreed not to reveal my identity and personal details if information about this project is published or presented in any public form.

I freely agree / do not agree *(strike out non-applicable)* to participate in this project according to the conditions in the Participant Information and Informed Consent Form.

I freely agree / do not agree *(strike out non-applicable)* to answer questions to determine the presence of psychiatric disorders.

I freely agree / do not agree *(strike out non-applicable)* to allow members of the Geelong Osteoporosis Study research team access to my medical records.

I freely agree / do not agree *(strike out non-applicable)* to allow members of the Geelong Osteoporosis Study research team access to my Medicare records.

I freely agree / do not agree *(strike out non-applicable)* to transfer ownership of my questionnaire and clinical data to the Geelong Osteoporosis Study research team.

I freely agree / do not agree *(strike out non-applicable)* to allow transfer of my de-identified questionnaire and clinical data to collaborators.

I freely agree / do not agree *(strike out non-applicable)* to allow transfer of my de-identified questionnaire and clinical data to commercial partners.

Participant’s Name (printed) ……………………………………………………

Signature Date

Declaration by researcher: I have given a verbal explanation of the research project, its procedures and risks and I believe that the participant has understood that explanation.

Researcher’s name (printed) ……………………………………………………

Signature Date

*Note: All parties signing the consent section must date their own signature.*
Participant Information and Consent Form

Full Project Title: 01/43_E2 Maternal vitamin D in pregnancy and childhood growth

Principal Investigators: Prof Julie A Pasco and Prof John D Wark
Associate Investigators: Dr Sharon L Brennan, Dr Peter Vuillermin, and Dr Lana Williams

1. Introduction

You and your child are invited to take part in this research project, which is an extension of the Vitamin D in Pregnancy Study, for which you have previously consented.

This Participant Information and Consent Form contain detailed information about this research project. Its purpose is to explain to you as openly and clearly as possible all the procedures involved in this project before you decide whether or not you and your child will take part in it.

Please read this Participant Information and Consent Form carefully. Feel free to ask questions about any information in this form.

Once you understand what the project is about and if you agree to take part in it, you will be asked to sign the Consent Form. By signing the Consent Form you indicate that you understand the information and that you give your consent to you and your child participating in the research project. You will be given a copy of the Participant Information and Consent Form to keep as a record.

2. What is the purpose of this research project?

This study is designed to provide information about maternal vitamin D levels during pregnancy and growth and wellbeing in the offspring at ages between 9 and 11 years. In this study we will determine the following in the mother-child pairs:

- bone and muscle development
- body shape, size and composition
- wheeze and lung function (child only)
- behavior
- physical and psychological symptoms/illnesses.

Approximately 400 child-mother pairs will participate in this phase of the project.
3. **What does participation in this research project involve?**

The child-mother participation in this project will involve completion of questionnaires and clinical measurements as follows:

- questionnaires will seek information concerning the child’s diet, physical activity, bone fractures, wheezing illnesses, food allergies, skin rash, immunisations, sun exposure, medication and supplement use, behaviour, physical and psychological symptoms/illnesses

- the child will self-rate physical maturity by matching the appearance of their bodies to Tanner charts

- a clinical assessment will include measurement of the child’s blood pressure, height, weight, circumference (waist, hip, head, limb), skinfold thicknesses, naevi (mole) counts, eczema

- the child’s muscle strength will be measured by grasping a hand-held meter (hand strength), resisting pressure on the legs using a manual muscle tester, and by asking them to complete some jumping and balance tests using a special plate on the floor (Ground Reaction Force Platform)

- a scan will be which measures the child’s bone mass in the spine, hip, forearm and total body to measure the calcium content of the bones, and the amount of fat and lean tissue in your child’s body, using a dual energy x-ray densitometer. The painless procedure takes approximately half an hour while your child is lying on an x-ray table

- a more detailed scan which will measure your child’s bone structure in the lower leg and forearm, and the size and mass of muscles, using peripheral quantitative computed tomography (pQCT). This is a painless procedure performed while your child is lying on an x-ray table. The pQCT scans and use of the Ground Reaction Force Platform will be performed at the Royal Melbourne Hospital, in Melbourne. This is the only part of the project not conducted at Barwon Health in Geelong. This part of the project is optional, should you and your child not wish to travel to Melbourne. Travel expenses from Geelong to Melbourne (return) will be available upon request.

- an ultrasound measurement for both yourself and your child at the heel. During this procedure your child will be required to place one foot in the ultrasound machine for a few minutes

- a lung function test which involves your child breathing into a device that can measure the amount of gas they are able to breathe out in one second

- mother’s diet, mental health and measured weight, height and waist circumference.

Data from this study may be used as reference data to identify risk factors for other diseases. Parts of this study may also be used for the purposes of obtaining an academic qualification. In the event that we establish collaborations (partnerships) with other researchers and/or commercial partners, your child’s and your information may be used for further research into health disorders. For such partnerships to work, it is important that you assign ownership of all the
information to the research team. If you wish, you may decline to have the information used by collaborators.

4. **What are the possible benefits?**

We cannot guarantee or promise that you will receive any benefits from this project but the information from the study may benefit people in the future.

5. **What are the possible risks?**

As part of your inclusion in this research the child will undergo DXA and pQCT scans that he/she would not normally receive and is therefore considered to be in addition to standard care. These DXA, pQCT and x-rays of your child’s body involve exposure to a very small amount of radiation. As part of everyday living, everyone is exposed to naturally occurring background radiation and receives a dose of about 2 millisieverts (mSv) each year. The effective dose from all these x-rays is about 0.032 mSv. At this dose level, no harmful effects of radiation have been demonstrated, as any effect is too small to measure. The risk is believed to be minimal. As your child is under the age of 18 years, you (or your child) should inform us of any other studies that he/she has participated in that involves the use of radiation. The ultrasound measurement is a rapid, painless procedure, not involving x-rays. The lung function test is neither painful nor distressful. The use of the Ground Reaction Force Platform is neither painful nor distressful, and does not involve any radiation.

6. **Do I and my child have to take part in this research project?**

Participation in this research project is voluntary. If you do not wish your child to take part, he/she does not have to. Similarly, if you, as a parent do not wish to take part, you do not have to. If you and/or your child decide to take part and later change your mind, you are free to withdraw from the project at a later stage. If you decide that your child will leave the project, the researchers would like to keep the personal and/or health information about you and your child that has been collected. This is to help make sure that the results of the research are accurate. Similarly, if your child provides body scans as part of this project, the researchers would like to retain these. However, if you do not wish for your child’s and your information to be retained, you must tell a researcher before withdrawing from the project. Your decision whether your child will take part or not, or to take part and then withdraw, will not affect your child’s or your routine treatment, your or your child’s relationship with those treating you or your and your child’s relationship with Barwon Health or Deakin University.

Before deciding whether or not to take part, you may wish to discuss the project with a relative or friend or your local health worker, and also with your child. Similarly, before you make your decision, a member of the research team will be available so that you can ask any questions you or your child may have about the research project. Once you feel confident that you have all the required information, you may then sign the Consent Form.

7. **How will I be informed of the final results of this research project?**

Periodically you will be sent newsletters summarising research findings and informing you of the progress of the project. Bone mineral density (DXA) results will be routinely sent to you and your doctor if you request it.
8. **What will happen to information about me and my child?**

Any information obtained in connection with this research project that can identify you or your child will remain confidential and will only be used for the purpose of this research project. Use of any information obtained in connection with this research project for future studies can only be used upon further approval from the Human Research Ethics Committee. The information will be retained for a minimum of 7 years after the completion of the study, in accordance with the Australian Code for the Responsible Conduct of Research (2007). After this period, all hard copies of data will be shredded and destroyed, and all data files will be permanently deleted.

Data will be de-identified prior to data analysis thereby preserving the privacy of all participants. Data will be collated into group findings for publication and at no time will any individual be identifiable.

The information will be stored in a locked archive room based at Barwon Health. This is a secure facility with limited access to staff members. Electronic data will be stored in databases password protected and accessible only to research staff.

9. **Can I access research information kept about me and my child?**

In accordance with relevant Australian and/or Victorian privacy and other relevant laws, you have the right to access the information collected and stored by the researchers about you and your child. Please contact one of the researchers named at the end of this document if you would like to access your information.

In addition, in accordance with regulatory guidelines, the information collected in this research project will be kept for a minimum of 7 years. Access to information about you and your child after this point will not be possible.

10. **Is this research project approved?**

This study has been approved by the Human Research Ethics Committee, Barwon Health. This project will be carried out according to the National Statement on Ethical Conduct in Human Research (2007) produced by the National Health and Medical Research Council of Australia. This statement has been developed to protect the interests of people who agree to participate in human research studies.

11. **Whom can I contact?**

If you want any further information concerning this project, please contact the Principal Investigator, Professor Julie Pasco on (03) 4215 3331 or the research centre on (03) 4215 3333.

If you have any complaints about any aspect of this project, please contact Bernice Davies, RGO/HREC Manager, (03) 4215 3372 or The Manager, Office of Research Integrity, Deakin University, (03) 9251 7129.
CONSENT FORM

01/43_E2: Maternal vitamin D in pregnancy and childhood growth.

Principal and Associate Researcher(s):
Julie A Pasco, John D Wark, Sharon L Brennan, Peter Vuillermin, Lana J Williams

I have read, or have had read to me in my first language, and I understand the Participant Information and Informed Consent Form Version 1C, Date: 5 Feb 2013.

The researcher has agreed not to reveal my child’s or my identity and personal details if information about this project is published or presented in any public form.

I freely agree/do not agree (strike out non-applicable) to my and my child’s participation in this project according to the conditions in the Participant Information and Informed Consent Form.

I freely agree/do not agree (strike out non-applicable) to answer questions to determine the presence of psychological symptoms/disorders.

I freely agree/do not agree (strike out non-applicable) to allow members of the research team access to my and my child’s medical records.

I freely agree/do not agree (strike out non-applicable) to transfer ownership of my and my child’s questionnaire and clinical data to the research team.

I freely agree/do not agree (strike out non-applicable) to allow transfer of my and my child’s de-identified questionnaire and clinical data to collaborators.

I freely agree/do not agree (strike out non-applicable) to allow transfer of my and my child’s de-identified questionnaire and clinical data to commercial partners.

I freely agree/do not agree (strike out non-applicable) to agree to be contacted in the future if there is a further follow-up study.

Parent/Guardian Name (printed) .................................................................

Signature Date

Declaration by researcher: I have given a verbal explanation of the research project, its procedures and risks and I believe that the participant has understood that explanation.

Researcher’s name (printed) .................................................................

Signature Date

Note: All parties signing the consent section must date their own signature.

Assent (optional)

Child’s Name (printed) .................................................................

Signature Date
Notification of Change to Protocol

PROJECT NUMBER: 01/43_E2
PROJECT TITLE: Vitamin D in Pregnancy (VIP) study - Maternal Vitamin D in pregnancy and childhood growth

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<td>Ref No</td>
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</table>

Expedited Ethical review application? Yes

NOTIFICATION OF:
Amendment no# Dated 08/08/2013

1. APPLICATION TO MODIFY REAC APPROVED PROTOCOL/ TRIAL DOCUMENTS

We are seeking an amendment to the existing project, numbered 01/43_E2 as follows.

Letter of invitation: We have changed one sentence to read: In this phase we will ask you and your child questions about diet, physical activity, sun exposure, behaviour, wheezing, allergies, health and well-being; and measure your child's growth and development of the skeleton and muscles, body size and lung volume. The letter of invitation has been renumbered accordingly to Version 1E, 8 August 2013.

PICF: We have revised our PICF (renumbered Version 1E, 8 August 2013) to more clearly align the Consent Form with the pre-approved Participant Information with respects to the following wording (new text is in red underlined font):

I freely agree/do not agree (strike out non-applicable) to participate in this project according to the conditions in the Participant Information and Informed Consent Form.
I freely agree/do not agree (strike out non-applicable) to allow members of the research team access to my child's medical records.
I freely agree/do not agree (strike out non-applicable) to allow transfer of my child's de-identified questionnaire and clinical data to commercial partners.

We have also clarified our Participant Information for consistency (renumbered Version 1E, 8 August 2013); Page 1 now reads:

The Barwon Health Human research Ethics Committee operates in accordance to guidelines established by the National Health and Medical Research Council.
This study is designed to provide information about maternal vitamin D levels during pregnancy and growth and wellbeing in the offspring at ages between 9 and 11 years. In this study, we will determine the following in the mother-child pair:

- Bone and muscle development
- Body shape, size and composition
- Wheeze and lung function
- Behavior
- Physical and psychological symptoms/illness.

**Questionnaire:** We wish to add questions relating to health literacy (an individual's ability to seek, access and understand health information), as this is an issue of key importance that may influence the growth and wellbeing in offspring. We have also included questions that require a true/false response, and pertain specifically to publicly accessible preventive health messages related to osteoporosis and the recommendations for healthy bones throughout the life-course. We also wish to add questions relating to perinatal/parental loss (using the Perinatal Grief Scale) and how this may have influenced the mother at the time and the possible impact this may have on the mother-child relationship and wellbeing. The revised questionnaire has been renumbered Version 1G, 8 August 2013, and is attached with this application.

**Protocol:** Our protocol has been renumbered to Version 1G, 8 August 2013, in order to reflect the addition of the questionnaires identified above. We have also included the revised version of the Ground Reaction Force Platform so as to more precisely measure the children's strength and balance.

2. **APPLICATION TO AMEND INVESTIGATOR/TRIAL STAFF DETAILS**

We request to add the following Investigator to this project: Dr Lana J Williams. We also wish to add Ms Lisa Burke as personnel. The expertise of Dr Lana Williams as a Clinical Psychologist and Psychiatric Epidemiologist will enhance the existing expertise of the investigator team, and her involvement as an Associate Investigator will specifically support the mental health aspects of this project. Accordingly, we have added Dr Williams' name to the PICF. Dr Williams will oversee and supervise Lisa Burke; the Research Assistant for this project who will conduct the psychiatric assessments, and who will be using part of the data to contribute to her Research by Higher Degree academic studies. Lisa Burke is enrolled as a student with Victoria University, however all data and analyses will remain be conducted onsite at the Barwon Health site of Deakin University. The CVs for both investigators are attached.

We have also taken the opportunity to update Julie Pasco's academic standing from Associate Professor to Professor.

**Participant Information and Consent Form**

Current approved version: **Version 1D, 5 April 2013**

Version to be used with this amendment: **Version 1E, 8 Aug 2013**
if a change to the above, please attach amended version bolding or underlining the amendment sections

<table>
<thead>
<tr>
<th>Principal Investigator</th>
<th>Study Coordinator</th>
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<tbody>
<tr>
<td>Name: Prof Julie Pesce</td>
<td>Name:</td>
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<tr>
<td>Signature</td>
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<td>Date: 8 August 2013</td>
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Received by the Research and Ethics Advisory Committee on 19/08/2013

The decision is: [ ] Approved [ ] Not approved [ ] Pending further information [ ] Letter(s) attached

HREC
BARWON HEALTH
PH: 03 4215 3374
e-mail:hrec@barwonhealth.org.au

Chris [Handwritten]

Jane [Handwritten]

Command: [Handwritten]

Support: [Handwritten]

15/8/13

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**HREC Amendment Form**

In the event that an ethically approved research project requires amendment, this form must be submitted to the reviewing HREC by the Coordinating Principal Investigator (CPI). The CPI is responsible for notifying all site Principal Investigators (PIs) of the amendment, in order for them to discuss it with their Research Governance Officer (RGO).

An amendment must not be implemented at a site until the HREC amendment has been approved by the reviewing HREC and (if applicable) Site Specific Assessment (SSA) amendment has been authorised at the site.

### Research Project Details

<table>
<thead>
<tr>
<th>HREC Reference Number</th>
<th>9201_E7_s1</th>
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<tbody>
<tr>
<td>Local Reference Number</td>
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<tr>
<td>Date of this Form</td>
<td>2 December 2014</td>
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<tr>
<td>Project Title</td>
<td>The epidemiology of osteoporosis in Australia: A population-based study in Geelong: Health Literacy in GOS Female Cohort Sub-study</td>
</tr>
<tr>
<td>CPI for Research Project</td>
<td>Prof Julie Pasco</td>
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<tr>
<td>HREC Approval Date</td>
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### Mode of HREC Approval

- [X] Single state only
- [ ] National Mutual Acceptance

### Sponsor Billing Address

N/A

### CPI Address

Epi-Centre for Healthy Ageing, Barwon Health University Hospital, PO Box 281, Geelong 3220

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### Amendment Details

Explain the changes that have occurred or are intended (may include changes in procedure, direction of project, source/manner of recruitment, number of participants or changes to research personnel)

We are seeking approval for a sub-study to an existing project (Barwon Health HREC 9201_E7). This sub-study (9201_E7_s1) involves contacting existing female participants of the Geelong Osteoporosis Study (GOS) to request they complete the 44 item 'Understanding of Health and Health Care' questionnaire. This questionnaire was developed and validated for use in an Australian population, and has previously been approved by the Barwon HREC for use in the 10 year follow up phase of the Vitamin D in Pregnancy study (Barwon Health HREC 01/43_F2).

We will mail the questionnaire identified above with a cover letter to participants. Alternatively, participants with internet access will be able to complete an online version of the questionnaire that is available through the password protected Barwon Health Research Electronic Data Capture (REDCap) system; an email with a link to the questionnaire will be sent to participants who have previously provided email addresses. Completion of the questionnaire will imply informed consent. We have provided the questionnaire, cover letter and email with this amendment.

Reason for the changes (include a comment on the impact on the research project and the participants at sites for which the reviewing HREC is responsible)

The completed 'Understanding of Health and Health Care' questionnaires will provide health literacy profiles for the participants in the study, giving us information on the ways in which participants source, understand and use health information as well as access health services. This information would then help to guide health organisations in tailoring health care messages and health services to improve their accessibility to the wider community.

Do these changes raise any ethical issues?

- [ ] Yes
- [X] No

If Yes, identify the ethical issues

---

HREC Amendment Form

August 2014

Page 1 of 3

Clinical Trial Research
List all amended documents to be reviewed.

<table>
<thead>
<tr>
<th>Document Title (include version number, if applicable)</th>
<th>Version Date</th>
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<tr>
<td>Participant Letter</td>
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<tr>
<td>Participant Email</td>
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<tr>
<td>Understanding of Health and Health Care Questionnaire</td>
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Attach one copy of each amended document to this form; all changes must be clearly indicated on the document(s).

Sponsor

Did a commercial sponsor initiate this amendment? ✓ No

Sponsor

Contact Person (Australia)

Email

Telephone

Drug/Device Research under the CTN Scheme

If this is a drug/device research project, does the amendment include additional and/or different drugs/devices or involve a new indication for any drug/device other than that approved in the original application? N/A

Supporting Departments

Does this amendment impact the type or frequency of service provided by a supporting department at participating sites? ✓ No

If Yes, indicate the relevant department(s)

- Anaesthesia
- EEG/EMG
- Medical Staff
- Pharmacy
- Anatomical Pathology
- Emergency
- Molecular Biology
- Physiotherapy
- Cardiology/ECG
- Endocrinology
- Nuclear Medicine
- Radiology
- Chemical Pathology
- Haematology
- Nursing Services
- Social Work
- Clinical Immunology
- Health Information
- Occupational Therapy
- Speech Pathology
- Clinical Pharmacology
- Interpreter Services
- Ophthalmology
- Tissue Typing

Other (please specify)

Provide written approval from the relevant department(s) to the Research Governance Officer at the relevant site(s).
Are all participating sites affected by this amendment?

If No, list all affected sites below.

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An amendment to ethically approved research may also impact the SSAs. The Research Governance Officer (RGO) at each affected site must be notified of the HREC amendment by their site PI to determine if the SSA needs to be amended. Final approval to implement an amendment at a site will be issued by that site’s RGO.

Declaration

I confirm that this project is being conducted in keeping with the conditions of approval of the reviewing HREC (and subject to any changes subsequently approved).

I confirm that the project is being conducted in compliance with the NHMRC National Statement on Ethical Conduct in Human Research (NHMRC, 2007) or as amended.

I confirm that I have not received any information in any form from anyone involved in the trial to suggest this report does not accurately reflect the progress of the project at the above site(s).

<table>
<thead>
<tr>
<th>CPI</th>
<th>Prof Julie Pasco</th>
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<tr>
<td>Organisation</td>
<td>School of Medicine, Deakin University</td>
</tr>
<tr>
<td>Email</td>
<td><a href="mailto:JULIEP@barwonhealth.org.au">JULIEP@barwonhealth.org.au</a></td>
</tr>
<tr>
<td>Telephone</td>
<td>(03) 4215 3331</td>
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HREC Acknowledgement (Office Use Only)

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