INFLUENCE OF PSYCHOSOCIAL FACTORS ON SOCIOECONOMIC GRADIENTS IN SELF-REPORTED ORAL HEALTH

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Dedication

To my parents,

Dr Aliasghar Zakershahrak and Dr Mehrazam Jamali

For their endless love and support and for encouraging me to pursue my dreams,

Thank you for instilling in me a love of learning

I am forever grateful.

and to Maciej,

for his love, support, and patience

“All men have stars, but they are not the same things for different people. For some, who are travelers, the stars are guides. For others they are no more than little lights in the sky. For others, who are scholars, they are problems… But all these stars are silent. You – you alone will have stars as no one else has them.”

The Little Prince by Antoine de Saint-Exupéry

Abstract

The robust association between socioeconomic status (SES) and health is well established. The gradient between SES and health tends to be higher at lower levels of SES. Individuals from low-income families (low economic status) are more likely to be affected by a wide range of health problems. Also, low-income people are more likely to experience chronic stress due to their income level (leading to many life challenges). Psychosocial factors are crucial resources for low-income groups in coping with stress and maintaining good health. Although studies have shown that protective psychosocial factors affect health, the influence of these factors on the association between income and health and quality of life requires further research. The aim of the thesis was to investigate the effects of protective psychosocial factors (i.e., sense of coherence (SOC) and personality traits) on income gradients in self-reported oral and general health and quality of life following Wilson and Cleary's conceptual model of health-related quality of life (HRQoL). Specifically, the main effect and interaction effect of these psychosocial factors and total household income on health and quality of life outcome measures were evaluated.

A total of five studies were conducted in this thesis to explore the aim using outcome measures in the order of Wilson and Cleary's model: (i) studies 1 and 2 investigated the effects of protective psychosocial factors (SOC and "Big Five" personality traits, respectively) and income on functional health, (ii) studies 3 and 4 investigated effects of SOC and personality traits (respectively) and income on general health perceptions, (iii) study 5 investigated effects of personality traits and income on the overall quality of life. All studies used the baseline data from the Dental Care and Oral Health Study (DCOHS, 2015-2016) collected by self-reported surveys sent to a random cohort of 12,245 South

Australian adults aged 18 years or older. Factorial ANOVA and multivariable Poisson regression models were used to conduct cross-sectional analyses.

Findings showed that SOC and personality traits were positively associated with better self-rated oral and general health and quality of life. The protective effect of these factors against poor self-reported health and quality of life was found at all income levels. Also, these psychosocial factors modified the association between income and health and quality of life outcome measures. Their modifying effect was associated with lower levels of poor self-reported oral and general health and quality of life across all income levels. However, there were greater health and quality of life gains (in absolute terms) for low-income individuals by having these protective psychosocial factors. The evidence provided by the current thesis suggests the possibility and importance of incorporating psychosocial factors into multidimensional programs to reduce health inequalities.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

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Dr Mehrsa Zakershahrak

7 / Oct / 2022

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Research outcomes

Publications resulting from research contained within this thesis

This thesis includes five research articles. One article has been published, and another has been accepted for publication. The other three research articles have been submitted and are currently under review:

1. Zakershahrak, M, Brennan, D. Personality traits and income inequalities in self-rated oral and general health. European Journal of Oral Sciences. 2022; 130:e12893.

2. Zakershahrak, M, Brennan, D. Effect of personality traits on socioeconomic inequalities in health, a population-based study. Community Dentistry and Oral Epidemiology. 2022 (accepted).
3. Zakershahrak M, Chrisopoulos S, Luzzi L, Jamieson L, Brennan D. Income and oral and general health-related quality of life: the modifying effect of Sense of coherence, findings of a cross-sectional study. Submitted to Applied Research In Quality Of Life. 2022.
4. Zakershahrak M, Chrisopoulos S, Luzzi L, Jamieson L, Brennan D. Sense of coherence, modifier of the association between income and self-rated oral and general health, a cross-sectional study. Submitted to Stress and Health. 2022.
5. Zakershahrak M, Chrisopoulos S, Luzzi L, Haag D, Brennan D. Can low-income people afford life satisfaction? The modifying effect of personality traits, a cross-sectional study. Submitted to Current Psychology. 2022.

Conference presentations related to research in this thesis

Zakershahrak, M., & Brennan, D. Effect of personality traits on socioeconomic inequalities in oral health-related quality of life. The 15th Annual Florey Postgraduate Research Conference. The Adelaide Convention Centre, Adelaide, Australia. 22nd September 2021 (poster presentation).

Zakershahrak, M., & Brennan, D. Personality traits, socioeconomic inequalities and quality of life in self-rated health. The Australian Public Health Conference. Virtual conference (due to COVID-19 outbreak). 23rd-24th September 2021 (E-poster presentation).

Zakershahrak, M., & Brennan, D. Is the association between income and oral and general health-related quality of life modified by sense of coherence? Findings of a cross-sectional study. The Australian Society for Medical Research Scientific Meeting. The Adelaide Convention Centre, Adelaide, Australia. 9th June 2022 (poster presentation).

Zakershahrak, M., & Brennan, D. Sense of coherence as the effect modifier of the association between income and oral and general health-related quality of life - Findings of a cross-sectional study. The 16th annual Florey Postgraduate Research Conference. The Adelaide Convention Centre, Adelaide, Australia. 21st September 2022 (poster presentation).

Zakershahrak, M., & Brennan, D. Personality traits modify the association between income and self-rated health. The 61st Annual Scientific Meeting of the International Association for Dental Research, Australia & New Zealand Division. The University of Melbourne, Melbourne, Australia. 26th – 28th September 2022 (poster presentation).

Awards resulting from this thesis

2022 Adelaide Dental School Prize. Florey Postgraduate Research Conference. Faculty of Health and Medical Sciences, the University of Adelaide.

2022 Eustace Travel scholarships, Adelaide dental school, the University of Adelaide.

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List of Abbreviations

ANOVA Analysis of variance

DCOHS Dental Care and Oral Health Study

EQ-5D European Quality of Life indicator or EuroQol

HRQoL Health-related quality of life

NSAOH National Survey of Adult Oral Health

OHIP Oral Health Impact Profile

OHRQoL Oral health-related quality of life

PRO Patient-reported outcomes

PROMs Patient-reported outcome measures

PR Prevalence ratio

RERI Relative Excess Risk due to Interaction

SES Socioeconomic status

SOC Sense of coherence

SRDH Self-rated dental health

SRGH Self-rated general health

SWLS Satisfaction With Life Scale

TIPI Ten-Item Personality Inventory

1 Chapter 1: Introduction

1.1 The concept of Health inequality

Social inequalities in health, notably those caused by income gradients, have been a widespread issue for decades (Marmot & Bell, 2016). A growing body of literature explores the association between socioeconomic status (SES) and health. Health follows a social gradient, with those lower on the social ladder having poorer health status and life expectancy than those higher up. The social determinants of health have received much attention in the past decade, particularly after the World Health Organisation launched the Social Determinants of Health Commission in 2005. The main report of this commission, *Closing the gap in a generation*, was published in 2008 (Commission on Social Determinants of Health, 2008), followed by the 2011 Rio Political Declaration on Social Determinants of Health (World Health Organization, 2011), which pledged efforts to reduce health inequities.

The term "health inequalities" denotes differences that adversely affect disadvantaged population groups, particularly socially disadvantaged groups (Arcaya et al., 2015; Kawachi et al., 2002). Given that the comparisons implicitly underpin the definition of health inequalities, established methods have always compared disadvantaged social groups with their privileged counterparts. These comparisons have extensively focused on the relationship between SES (such as income, education, employment status, and living conditions) and health outcomes, indicating that low SES is associated with poor health and an increased risk of morbidity (Marmot & Bell, 2016).

Health inequalities can occur at any stage of life and unfairly affect people's opportunities for good health and quality of life (Trannoy et al., 2010). Jusot et al. (2013) found that

46% of social inequalities in health result from unequal opportunities related to childhood circumstances. Part of the Gross Domestic Product (GPD) is spent on welfare losses caused by health inequality, which results in economic and social costs to society (Mackenbach et al., 2011). Also, developing better policy interventions could potentially reduce these inequalities (Woodward & Kawachi, 2000). Therefore, finding effective solutions to tackle health inequalities is a major concern for governments and policymakers. To better understand SES inequalities in health, a multidisciplinary approach to address them is imperative.

Health inequalities can be explained by material (e.g., income), behavioural (e.g., personal lifestyle choices and health-related behaviours), and psychosocial factors (e.g., individual dispositional factors and personality characteristics). Studying health inequality requires a deeper understanding of the relationship between socioeconomic, behavioural, and psychosocial factors. The main factors contributing to poorer health in socioeconomically disadvantaged groups encompass lower education levels, lower income levels, and higher unemployment rates (Tsakos et al., 2011; Watson & Nilam, 2017).

1.2 Health inequalities and income gradients

Income gradients in oral and general health are well established (Bernabé et al., 2015; Sabbah et al., 2007), showing that households with lower incomes have poorer general and oral health than those with higher incomes. There are similarities in the SES gradient in subjective oral and general health (Borrell et al., 2004; Sabbah et al., 2007). The gradient between SES and oral and general health tend to be higher at lower levels of SES (low income and education) (Sabbah et al., 2007). Also, the SES gradients "were attenuated" after adjusting for confounders (namely sociodemographic variables, smoking, health insurance, and diabetes) but still were present (Sabbah et al., 2007). Also, the link between oral and general health has been explored, showing that they have common risk factors and poor oral and general health influence one another (Sabbah et al., 2019).

Low-income households report poorer self-ratings and higher general and oral health problems (Mejia et al., 2014; Sabbah et al., 2007; Tsakos et al., 2011), such as heart disease (Blackwell et al., 2014), diabetes (Blackwell et al., 2014), asthma and its complications (Simon et al., 2003), physical disability and limitations (Marra et al., 2004), obesity and related health problems (Speirs et al., 2016), higher rates of tooth loss (Seerig et al., 2015), higher risk of oral cancer (Conway et al., 2008), periodontal problems (Sabbah et al., 2009) and greater prevalence of untreated dental decay (Dye & Thornton-Evans, 2010; Mejia et al., 2018; Sanders, 2008). According to Chetty et al. (2016), life expectancy has increased by about 2.5 years over the past two decades for the top 5% of the income distribution but not for the bottom 5%. They also found that health behaviours and environmental characteristics were associated with life expectancy differences. Sabbah, et al. (2009) found that the income-related inequalities in oral health outcomes were still observed after adjusting for oral health behaviours, suggesting the complexity of the underlying factors.

On the other hand, the impact of health problems (poor health) on low-income households can be devastating. Disruption of employment (negative impact on household income), additional financial burdens for the household (e.g., increased health care expenses), and additional household responsibilities (e.g., caring for a sick family member) can all have detrimental effects on low-income households.

1.2.1 How income affects health

Low income affects health through several mechanisms. To better understand the relationship between low income and poor oral and general health, three broad categories of factors are considered: clinical, behavioural, and environmental (Sisson, 2007). Behavioural and environmental factors are closely intertwined.

1.2.1.1 Clinical factors

These factors refer to income-related disadvantages (e.g., difficulty affording preventive healthcare and treatments). Low-income individuals face greater barriers due to income disadvantages when seeking medical care than those with higher incomes, namely, low probability of having health insurance, and access to primary and speciality healthcare services (such as new medical technologies and medication) (Andersen et al., 2002). Health benefits are less likely to be offered by their employers (Shartzer et al., 2018). Due to cost concerns, those low-income individuals without health insurance are less likely to receive regular medical care (McWilliams, 2009). Sanders reported that low-income Australian adults had less access to private health insurance (due to their inability to afford it) and therefore had to rely on public services or pay the fixed fees for private dental care out of pocket (Sanders, 2008).

It should be noted that these factors are based on the "materialist" explanations (Sisson, 2007), which are different from the "material" explanations (Macintyre, 1997). The material explanations argue that income and wealth are the primary determinants of health inequalities and explain the link between SES and material resources (e.g., food, housing, services, and other essentials) (Davie et al., 1972; Sisson, 2007). On the other hand, materialist explanations focus on the individuals' SES-related factors, such as limited access to healthcare due to socioeconomic disadvantages (e.g., financial hardship) (Blane et al., 1997; Sisson, 2007).

1.2.1.2 Behavioural and environmental factors

Behavioural factors focus on unhealthy behaviours and risk factors (e.g., smoking, drinking, unhealthy diet, lack of exercise) that are more prevalent among low-income groups (Lynch et al., 1997; Martikainen et al., 2003). According to the behavioural explanations, low-income individuals are more likely to engage in health-damaging behaviours, resulting in poorer health and higher rates of health problems (Sanders, 2008). Also, environmental factors such as challenging living conditions and poor neighbourhoods significantly affect behavioural risk factors. The possible underlying reasons could be a combination of some of the following explanations:

(i) Inadequate education and knowledge, limited learning opportunities, and negative attitudes towards healthy behaviours (Pampel et al., 2010; Singh et al., 2019);

(ii) Low-income individuals have difficulty affording healthy activities (such as the gym) and healthy diets (fruits, vegetables, and less sugar, which are more expensive (Drewnowski & Specter, 2004) and less filling than cheap refined carbohydrate products with high sugar (Turrell, 1998)). Also, as opposed to poor access to healthy foods (Larson et al., 2009), they have easier access to energy-dense foods and fast-food restaurants (Turrell et al., 2002).

(iii) Living in a poor neighbourhood due to low income gives low-income individuals greater access to tobacco sellers (Yu et al., 2010). Poor neighbourhoods typically have more tobacco retailers due to historically used marketing strategies (Brown-Johnson et al., 2014; Yu et al., 2010).

(iv) Low-income communities lack shared spaces that promote physical activity (e.g. parks, sidewalks and bike paths) (Dahmann et al., 2010).

(v) Their living conditions limit their access to cessation counselling services, while they experience high chronic stress because of their stressful life situations (Robinette et al., 2016).

(vi) Low-income people are also more likely to experience high levels of stress and stressful life situations (Evans et al., 2005) (e.g., due to financial and material hardship and living conditions and neighbourhood (Robinette et al., 2016)), which are linked to (and promote) unhealthy behaviours and poor dietary habits (Lampard et al., 2013; Lumeng et al., 2014; Michels et al., 2012).

1.3 Health inequalities from the psychosocial perspective

The psychosocial perspective is also used to explain health inequalities, according to which psychological stress is experienced differently by people from different SES (Kawachi et al., 2002). It should be noted that low-income groups are more likely to experience a high level of long-term chronic stress (such as long-term unemployment or the stress associated with affordability and living conditions) (Aneshensel, 2009; Steptoe & Feldman, 2001). Also, it is more difficult for low-income individuals to overcome barriers they face since they have less power and resources (such as difficulty affording health care because of low income). The variance in health could be explained beyond conventional risk factors (e.g., health behaviour) through psychosocial factors, which are interconnected determinants of health and quality of life. Psychosocial factors are described in a separate section (See 1.7).

Psychosocial epidemiology investigates how interactions with the social environment affect people's health. Psychosocial factors influence individuals through psychological mechanisms/responses to social conditions. Individuals' interactions with their social environments can directly (such as through biological responses to stress) or indirectly (i.e., through health behaviours) affect their health (Siegrist & Marmot, 2004). The direct pathway is also reflected in the notion of biological embodiment. This concept was developed by Krieger (2005) from the biopsychosocial paradigm (which is explained in subsection 1.3.2). The biological embodiment framework argues how adverse social conditions and socioeconomic disadvantages can trigger pathobiological reactions, negatively impact the biological system, and ultimately result in health problems and disease (Adler & Ostrove, 1999; Krieger, 2005). Chronic stress plays a significant role in this concept: as a response to socioeconomic adversity, which can lead to health problems or an elevated risk of disease (Blane et al., 2013).

Psychosocial theories significantly influence public health policies by addressing the role of psychosocial factors in response to stress (Egan et al., 2008). A range of different explanations and models with a focus on psychosocial factors have been posited to shed light on health inequalities. It is important to note that despite their differences in details, they all acknowledge the role of psychosocial factors in the association between SES and health. These contemporary explanations should not be considered as competing approaches but rather as different aspects contributing to a broader understanding of the underlying issues of health inequalities (Sanders, 2008).

1.3.1 Psychosocial environment

According to the "psychosocial environment", the factors contributing to health inequalities go beyond material determinants. The "psychosocial environment" explanation states that damaging, undesirable and stressful life situations, restricted control over life, and limited social support lead to poorer health outcomes for socioeconomically disadvantaged people (Soskolne & Manor, 2010). As one of the most important explanations for health inequalities, this concept highlights the influence of psychosocial and environmental factors in relating SES to health through mediating links to health-related behaviours and biological reactions. In other words, health inequalities can be exacerbated by poor psychosocial environments, i.e., through the combined influence of psychosocial and environmental factors (such as SES) on health (White, 2005). Therefore, individuals' coping mechanisms against stress (i.e., response to stress) within the psychosocial environment affect their health.

1.3.2 Biopsychosocial model

The biopsychosocial model focuses on the person's perception of their health and how they cope with health problems and stressors. Engel (1977) proposed this model as a holistic alternative to the traditional biomedical model, a biological approach to disease that focuses on treatment (Fava & Sonino, 2007). In his perspective, biological responses are not the only contributory factor to disease. The biopsychosocial model considers biological, psychosocial, and social factors as interconnected determinants of health and disease (Fava & Sonino, 2007). As opposed to treating the disease as an isolated issue, this model considers the whole person affected by many factors and experiences (Molyneux, 2022). Among psychosocial factors, stressful life situations, repeated exposure to environmental stressors, psychological distress, psychological wellbeing, and resilience could be considered (Fava & Sonino, 2017).

The biopsychosocial model argues that chronic stressors (e.g., low SES) can interact with psychosocial factors to cause stress-related biological reactions (e.g., inflammatory and hormonal responses). The biological responses to stress could be hormonal, such as increased cortisol levels. The disruption of cortisol production is associated with health problems, such as obesity (Miller et al., 2013). This interaction between low SES-related stressors with psychosocial factors adversely affects health (Bolton & Gillett, 2019). This model provides insight into the individual's perception of their health, attitudes towards it, and coping strategies (such as preventions, treatments and follow-ups). The biopsychosocial model explains how people's reactions, their psychosocial resources and the interaction between their social and psychological factors could affect health.

A paradigm shift from the biomedical to the biopsychosocial health model has led to the development of subjective health and wellbeing measures. The biopsychosocial model's significance can be explored from a patient-centred perspective. Patients' subjective experiences and perceptions regarding their health have become an integral part of an accurate diagnosis and treatment (Engel, 1977).

1.4 Patient-reported health outcomes

Patients' perspectives have become increasingly important in measuring health outcomes in the last few decades. In tandem with the development of the biopsychosocial model, patient-based outcomes have received increased attention, with a focus on health-related quality of life (HRQoL) (Brennan et al., 2019). The term "patient-reported outcome" (PRO) refers to "any report of the status of a patient's health condition that comes directly from the patient without interpretation of the patient's response by a clinician or anyone else" (Food and Drug Administration, 2006). Patient-reported outcome measures (PROMs) are the instruments that measure PROs using self-report questionnaires (usually). Healthcare decision-makers should access the data collected using PROMs to ensure they know the outcomes that matter most to patients. PROMs could be generic (evaluate general aspects of health) or disease-specific (evaluate the aspects of health related to a specific disease) (Fayers & Machin, 2013). Some of the most common PROMs are generic, such as the Short Form 36 (SF-36) (Ware Jr & Sherbourne, 1992) and the EuroQol (EQ-5D) (Van Reenen et al., 2018). Such instruments generally measure several domains and generate a profile of scores.

Patient-reported health outcomes are defined as health measures (i.e., PROMs) from the patient's perspective (patient's perception and interpretation of their health, i.e., subjective health) (Fayers & Sprangers, 2002; Valderas & Alonso, 2008). These health measures include several self-reported instruments which assess patients' perceptions of their health, the symptoms they are experiencing and recommended treatment effects (Williams et al., 2016). By using patient-reported health outcomes, researchers can better understand the effect of healthcare interventions and treatments from the patient's perspective (Williams et al., 2016). Also, some important health outcomes are not directly (or physiologically) measurable and are required to be assessed through these instruments (e.g., the perception of pain and depression) (Williams et al., 2016). Therefore, patient-reported health outcomes provide valuable insights and a better understanding of the individual's health over objective health evaluations (professional assessments such as blood tests) (DeWalt & Revicki, 2008).

A wide range of health-related concepts can be assessed using PROMs (Cella et al., 2015), namely:

(i) HRQoL reflects the multidimensional construct of the individual's health, including physical, mental, social, and emotional wellbeing (Torrance, 1987). This concept is well defined by Patrick and Erickson (1993): "the value assigned to the duration of life as modified by the impairments, functional states, perceptions, and social opportunities that are influenced by disease, injury, treatment, or policy."

(ii) General perceptions of health and wellbeing (Fayers & Sprangers, 2002);

(iii) Functional status describes the behaviours and abilities to perform specific tasks and activities, namely: physical and cognitive functions (Cohen & Marino, 2000).

(iv) Symptoms are usually categorised as symptoms associated with disease and/or treatment (Cleeland, 2007). They encompass different types of symptoms: physical, psychophysical, and psychological.

(v) Quality of life reflects the individual's perception of all aspects of their lives and how different factors affect their overall quality of life and satisfaction (McKenna, 2011). The World Health Organisation describes it as "individuals' perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns" (WHOQOL Group, 1995).

(vi) The patient's experience reflects the individual's experience with health care and their satisfaction with care, treatment and services (Lewis, 1994).

Several conceptual models have been developed to explain the interrelationship between various patient outcome measures. Among them, Wilson and Cleary's conceptual model presented a taxonomy of patient outcome measures based on their underpinning health concepts (Wilson & Cleary, 1995). Their model presented particular causal relationships between different health concepts through the integration of biopsychosocial and quality-of-life models (a social science paradigm focusing on wellbeing and functioning dimensions) (Wilson & Cleary, 1995).

1.5 Wilson and Cleary's conceptual model of HRQoL

A conceptual model integrating psychosocial and clinical approaches to health care was proposed by Wilson and Cleary (1995) (Figure 1.1). They developed a model to assess health outcomes that links biological and physiological factors (objective health) to HRQoL (subjective health) (Ojelabi et al., 2017). Their conceptual model is the most cited framework of HRQoL in the literature (Bakas et al., 2012; Ferrans et al., 2005; Villalonga-Olives et al., 2014). A key feature of their conceptual model is the incorporation of concepts of the biopsychosocial model and PROs by highlighting the role of characteristics of the individual and environment in explaining the causal relationship between health and quality of life (Ojelabi et al., 2017). This model suggests a relationship between the individual's characteristics ("patient-specific factors" such as personality) and their functional health, HRQoL, general health perceptions, and overall quality of life (Wilson & Cleary, 1995). This consistent model is applicable to all individuals regardless of their age and health status, and the real-world application of the model is plausible (Bakas et al., 2012).

1.6 Maintaining good health despite low income

Despite the given explanations about the income inequalities in health, it should be noted that some low-income individuals are able to maintain good health even with severe stressors resulting from low income (Bonanno, 2005; Chen et al., 2011; Mizuta et al., 2020). Also, this is not to claim that "all" low-income individuals are necessarily prone to health-damaging behaviours because of the explanations provided about behavioural and environmental factors affecting their health. Speirs et al. (2016) reported that not all low-income individuals lead unhealthy lifestyles and engage in unhealthy behaviours. Although low-income people are at an increased risk for poor health and unhealthy behaviours, some remain healthy and adopt health-promoting behaviours regardless of the limited resources available to them due to their socioeconomic disadvantage (Speirs et al., 2016). Research has shown that some low-SES individuals remain healthy despite facing socioeconomic adversity and even dealing with chronic diseases (such as asthma (Chen et al., 2011)), cumulative physiological risk (allostatic risk (Chen et al., 2012)), and common cold (Cohen et al., 2004).

In light of these findings, the factors that could protect the health of those who face socioeconomic adversity and hardship should be considered. It should be borne in mind that stress plays a key role in psychological mechanisms that connect low SES to poor health (Adler et al., 1994; Chen, 2004). Also, as explained earlier (See 1.3), low-income people are more likely to experience a high level of long-term chronic stress. More importantly, an individual's ability to cope with stress effectively is influenced by psychosocial factors (Carver & Connor-Smith, 2010) (i.e., protective psychosocial factors that help effective coping with stress; See 1.7). Protective psychosocial factors are valuable resources for low-SES people in coping with stressors (Adler & Snibbe, 2003).

Therefore, some low SES individuals may have enhanced and effective coping responses (strategies) to stressors as the result of having protective psychosocial factors. Studies have shown that people who are able to cope with chronic stress from low-SES situations successfully are equipped with psychosocial factors (psychological characteristics) that protect them from poor health or disease (Atal & Cheng, 2016; Cohen et al., 2004; Mizuta et al., 2020; Speirs et al., 2016). Low-SES people have limited resources and face many barriers, so they could reap benefits from protective psychosocial factors as valuable resources in coping strategies with chronic stress (Adler & Snibbe, 2003; Mizuta et al., 2020). This perspective is consistent with the individual differences in psychological responses and/or coping mechanisms to stress.

Also, not all low-SES individuals have protective psychosocial factors that could help improve coping with stress. This is another reason for the robust association between low SES and poor health. However, studies have shown that even among low-SES people, some individuals have protective psychosocial factors, and therefore they "beat the odds" and have efficient coping mechanisms which could protect them against the adverse effects of socioeconomic disadvantage on health (Atal & Cheng, 2016; Chen et al., 2012; Cohen et al., 2004; Mizuta et al., 2020; Speirs et al., 2016; Turiano et al., 2014). Moreover, a study by Makoge et al. (2019) assessed the factors associated with coping with health challenges. They showed that social factors and income were not associated with the coping ability of individuals who were in poverty (due to their low income). These authors argued that the coping strategies of those in poverty against diseases were strongly influenced by their protective psychosocial factors (Makoge et al., 2019). The study by Lachman and Weaver (1998) revealed that low SES adults with higher levels of protective psychosocial factors (perceived control) had better self-reported health and experienced fewer acute physical symptoms and functional limitations than those with low SES with lower levels of these psychosocial factors. Most importantly, their self-reported health outcomes, acute physical symptoms and functional limitations were very similar to those of high SES groups. Low-income families with protective psychosocial factors tend to engage in healthy behaviours (such as a healthy diet) and health-promoting activities (such as physical activities) and handle stressful situations better, which in turn help them to remain healthy (despite their limited resources) (Speirs et al., 2016). A study by Mizuta et al. (2020) showed that protective psychosocial factors are able to significantly improve dental health for those who live below the poverty line. They reported an association between the protective psychosocial factors of low-income Japanese guardians and lower caries prevalence among their children (Mizuta et al., 2020). Protective psychological factors can buffer the adverse health effects of low SES (Atal & Cheng, 2016; Chen et al., 2011; Lachman & Weaver, 1998). Also, protective psychosocial factors can protect children against the adverse dental caries effects of low SES (Tomazoni et al., 2019).

These findings provide empirical evidence which suggests that protective psychosocial factors could confer significant health benefits among those affected by socioeconomic adversity (such as low income) (Zilioli et al., 2017). Besides, the association between low income, health and quality of life can be explained by psychosocial factors, which could act as effect modifiers (previously known as moderating factors (Knol & VanderWeele, 2012)) rather than mediating factors (Zilioli et al., 2017).

1.7 Psychosocial factors

In health research and social epidemiology, the term "psychosocial" broadly refers to factors related to an individual's psychological characteristics and social environment that influence health (Long & Cumming, 2013). The psychological characteristics influence individuals' mechanisms/responses to social factors (e.g., SES). Social factors refer to the individual's relationship (interaction) with their environment, namely: SES, neighbourhood characteristics, race, and family background (Long & Cumming, 2013). The psychosocial factors comprise protective psychological resources (such as self-efficacy, personal control, personality traits and sense of coherence (SOC)) and psychological risk factors (such as stress, anxiety, depression and hopelessness) (Thomas et al., 2020). The significant role of psychosocial factors in population health has been shown (Kawachi, 2002; Marmot & Siegrist, 2004). While psychosocial risk factors (particularly stress) negatively affect oral and general health (Acabchuk et al., 2017; Brennan et al., 2019; Marcenes & Sheiham, 1992), personality traits (Huang et al., 2017; Thomson et al., 2011) and strong SOC (Flensborg-Madsen et al., 2005; Savolainen et al., 2009) (as psychosocial resources) have been documented to have positive effects. When faced with socioeconomic adversity that exacerbates several factors that lead to poor health and quality of life, psychosocial resources play an important role (See earlier 1.6). In this thesis, the terms "strong" and "weak" in this context refer to the relative strength of the protective psychosocial factors (such as SOC and personality traits) which could influence successful coping with stress, not to imply any value judgement as to the worth of individuals (or somehow complicit as victims).

1.7.1 Sense of coherence

Evidence of positive health outcomes in adverse circumstances has led to a paradigm shift from a pathogenic model to a model based on health and wellbeing. In 1979, Aaron Antonovsky introduced the concept of "Salutogenesis-of the origins of health" in his book *Health, Stress and Coping* (Antonovsky, 1979). He flipped the conventional question of what causes diseases and asked what factors enabled people to remain healthy even in challenging and difficult environments (adverse situations) (Antonovsky, 1979, 1987, 1995). His Salutogenesis model was inspired by a number of survivors of concentration camps of the Second World War that maintained good health and life despite what they had been through (Lindström & Eriksson, 2006). The fundamental concepts of the Salutogenic model are the SOC and general resistant resources (GRR) (Antonovsky, 1979, 1987, 1993).

SOC is the individual's adaptive dispositional orientation (personality disposition) that reflects the ability to cope with stressors and adverse experiences (Volanen, 2011). SOC is the individual's outlook on life that enables them to perceive external and internal life's stressors as: (i) comprehensible (i.e., understandable, predictable, explainable and ordered), (ii) manageable (i.e., the ability to manage stressors and having sufficient and available resources to cope with them), and (iii) meaningful (viewing stressors as challenges worthwhile to engage with and cope with) (Antonovsky, 1987, 1993). According to Antonovsky, four types of life experiences can influence SOC development (Idan et al., 2017). These are consistency (comprehensibility component), load balance (manageability component), participation in shaping outcomes (meaningfulness component) and emotional closeness (meaningfulness component) (Idan et al., 2017). The life experiences related to the meaningfulness component are based on the importance of an individual's power, role and participation in decisions related to their future and emotional bonds, closeness, and belonging to their social groups (Idan et al., 2017).

Strong SOC (referring to the relative strength of the concept of SOC, i.e. high coherence) can mitigate and ameliorate stress by affecting coping strategies (Kaplan, 2005). People who have strong SOC are better able to control their life situations (particularly the challenging and difficult ones) (Richardson & Ratner, 2005). They are more capable of coping with daily stress than others (Super et al., 2016). Furthermore, they are more likely to have a positive attitude and viewpoint and higher self-esteem, which are key to effectively managing stress (Bernabé et al., 2009). They adopt healthy behaviours and health-promoting approaches (resulting from strong SOC), which enable them to cope with stressors that affect their health (regardless of the limited resources available (Speirs et al., 2016)). They are more resilient to health problems when faced with similar adverse situations. Strong SOC is associated with better health outcomes (Eriksson & Lindström, 2006). SOC has modifying effects (previously known as moderation effects) on health in stressful circumstances (Eriksson & Lindström, 2006).

According to Antonovsky (1987), GRRs are "phenomena that provide one with sets of life experiences characterised by consistency, participation in shaping outcomes and an underload-overload balance". GRRs are manageability, meaningfulness and comprehensibility resources. To put it simply, GRRs are life experiences and resources that influence and shape SOC, including social support, knowledge and intellectual resources, financial resources, coping strategies, self-identity, cultural factors (such as cultural commitment, cohesion, and stability), sense of belonging, ritualistic practices, religion and spirituality, and individual's mentality (Horsburgh & Ferguson, 2012; Idan et al., 2017). GRRs improve individuals' health by helping them adopt healthy behaviours (e.g., healthy diet, regular exercise and physical activities, regular health check-ups) and helping them avoid risky behaviours (e.g., smoking, unhealthy lifestyle and diet, heavy drinking) (Savolainen et al., 2009).

Despite the importance of manageability resources (financial factors), they are not the only resources to help people cope in the face of adversity. In difficult economic circumstances (such as low income), individuals' successful coping abilities are influenced by other GRRs more than just their financial resources. It is extraordinary just how little manageability resources are needed if the sense of meaningfulness is strong. In a study of unemployed migrant women (Slootjes et al., 2017), strong SOC was linked to the meaningfulness of what they had been through (their experiences) and GRRs, including social support, religion, sense of belonging, helping others and shared narratives of empowerment. These resources helped them feel more consistent, get a better load balance, and find meaning in challenging situations than those with weak SOC (referring to the relative strength of the concept of SOC, i.e. low coherence) (Slootjes et al., 2017). Also, SOC has been shown to be affected by healthy behaviour regardless of individuals' education and social class (Wainwright et al., 2007). In a study by Makoge et al. (2019), the coping ability of poverty-stricken individuals was strongly associated with their SOC (as the individual's dispositional factors) and not associated with their income and social factors. Low-income families who have strong SOC were shown to adopt health-promoting behaviours, avoid unhealthy behaviours and cope with stress more successfully than those with weak SOC (Speirs et al., 2016). These families had good family functioning or resilience, and SOC could help them be resilient to environmental factors (such as inadequate physical activity spaces and easier access to energy-dense foods) (Speirs et al., 2016). Strong SOC can also protect children from the detrimental effects of low SES on dental caries (Tomazoni et al., 2019).

1.7.2 Personality traits

The reason some individuals have different reactions to stress in similar life situations than others could be explained by their dispositional personality traits (Costa et al., 1996). It should be noted that although SOC and personality traits are correlated, these two concepts are not exactly the same (explained further in the discussion section, See 9.2). An individual's ability to successfully cope with chronic stress in low SES life situations results from their personality traits and coping behaviours (Bosma et al., 1999; Körner et al., 2003). Personality traits reflect one's characteristic patterns of thoughts, feelings, actions, and behaviours (Chapman et al., 2011). There are several ways to define personality, but most researchers use Allport's definition (1961): "Personality is a dynamic structure within the person consisting of psychosocial-physical systems determining their characteristic behaviours and thoughts."

In the past, researchers tried to identify personality traits to evaluate people's behaviour. Gordon Allport (one of the pioneers in studying traits) found over four thousand words that described different traits, which he classified into three levels (Mautz et al., 2020). A simplified version of Cattell's sixteen main personality traits was still too complicated (Cornwell & Greenidge, 2020). Later, a five-dimension personality model was developed and further explained by several researchers (Such as Goldberg, McCrae and Costa), also known as the "Big five" (Digman, 1990). The "Big five" refers to the five main traits that interact to form the individual's personality and are associated with the coping mechanisms (Connor-Smith & Flachsbart, 2007; Kardum & Krapić, 2001), known as the acronym CANOE or OCEAN:

(i) Openness to experience: being open-minded, curious, having mental adaptability and flexibility, and willing to embrace new experiences;

(ii) Conscientiousness: being self-organised, responsible, diligent, goal-directed and reliable;

(iii) Extraversion: having positive emotions, enthusiasm and the ability to socialise and interact with others;

(iv) Agreeableness: affinity for affection, trust, cooperation and altruism and helping others; and

(v) Neuroticism (as opposed to emotional stability): having negative emotions, being emotionally unstable, irritability, moodiness, and tendency to experience sadness and anxiety (Funder, 2013).

The association between high scores for openness, conscientiousness, extraversion, and agreeableness and low scores for neuroticism (i.e., high scores for emotional stability) with better oral and general health have been reported (Stephan et al., 2020). Individuals with strong extraversion, conscientiousness, openness and agreeableness regularly engage in more physical activity (Rhodes & Smith, 2006) and have healthy diets (Weston et al., 2020) compared to those with weaker traits (referring to the relative strength of the concept of personality traits) that lead to better health (Stephan et al., 2020). Strong neuroticism is associated with poor wellbeing and health as well as a high level of depression, stress and health complaints (Löckenhoff et al., 2012; McCrae & Costa, 2003). Those with strong neuroticism do not exercise regularly and have risky health behaviours (unhealthy diet, smoking, excessive alcohol consumption) that negatively affect their health (Elran-Barak et al., 2019; Stephan et al., 2020). Strong conscientiousness and agreeableness are positively associated with healthy behaviours as well as less drinking and smoking (Allen et al., 2015).

Personality traits play an important role in influencing adaptive behaviours and coping mechanisms under stressful circumstances. Strong conscientiousness and agreeableness are positively associated with effective coping strategies (Bartley & Roesch, 2011; Karimzade & Besharat, 2011). Individuals with strong extraversion (Vollrath, 2001) and openness (Penley & Tomaka, 2002) use active coping strategies in stressful situations. On the other hand, strong neuroticism is associated with poor coping mechanisms (Costa et al., 1996).

Given that living with low income leads to a greater chance of experiencing negative experiences and high stress, having personality traits that help individuals cope effectively with stressors, be more stable, and make better health choices would be beneficial to those with low incomes. The significant role of personality traits as beneficial psychosocial resources for low-SES individuals has been reported (Atal & Cheng, 2016; Chapman et al., 2011; Elliot et al., 2017; Packard et al., 2012). The effect of social adversity on health for individuals with personality traits related to poor health (such as neuroticism) is greater (more robust) than for others (Chapman et al., 2011). On the other hand, healthy behaviours such as a healthy diet are significantly influenced by personality in low-SES individuals (Packard et al., 2012). Low-income individuals can develop effective psychological responses (such as adaptive strategies or coping mechanisms) to stress from their living conditions and environment. Also, they can gain skills that enhance their ability to cope with adversities in their lives.

1.8 Rationale

Psychosocial factors could play an essential role in connecting SES and health (Matthews et al., 2010). Exposure to chronic stressors (such as low-income status) and coping responses to stress affect health from a psychosocial perspective. When faced with stressful situations, protective psychosocial factors such as SOC and personality traits significantly impact adaptive behaviours, coping strategies and stress-related responses (Atal & Cheng, 2016; Makoge et al., 2019; Mizuta et al., 2020; Speirs et al., 2016). Low-income individuals could have different coping capabilities in terms of health challenges (Makoge et al., 2019). However, protective psychosocial factors can enhance low-income people's coping abilities when faced with stressors caused by SES adversity (Makoge et al., 2019). Identifying factors influencing health outcomes and coping abilities among low-income groups could improve efforts to address health inequalities. However, limited research is available on the effect of psychosocial factors (e.g., SOC and personality traits) on socioeconomic gradients in health. Also, there is a lack of assessment and recognition of psychosocial pathways in policy and practice to reduce health inequalities using a multidimensional approach. Therefore, it is necessary to investigate the impact of protective psychosocial factors, such as SOC and personality traits, on the potential health gains for low-income groups. This evaluation would also provide a better understanding of the role of protective psychosocial factors in the association between income with health and quality of life. Also, assessing the effect of protective psychosocial factors on the association between income with health and quality of life may help improve the multidimensional approach to addressing health inequalities from a policy perspective.

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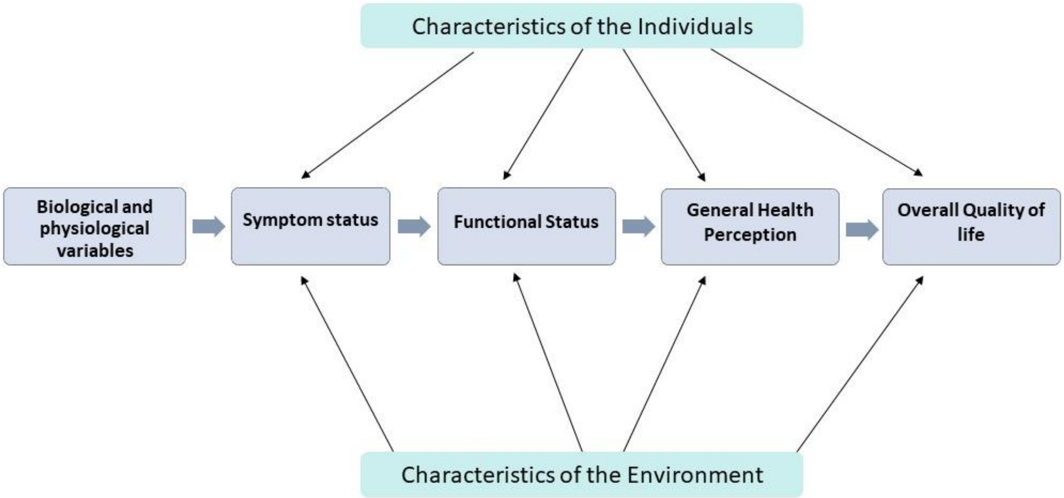

Figure 1.1 The conceptual model of health-related quality of life by Wilson and Cleary (1995).

2 Chapter 2: Thesis scope, general aim and specific objectives

2.1 General aim

Under the broad objective of evaluating the influence of psychosocial factors on socioeconomic inequalities in health, this thesis investigated the effects of protective psychosocial factors related to personality traits and sense of coherence (SOC) on income gradients in self-reported oral and general health and quality of life following Wilson and Cleary's conceptual model of health-related quality of life (HRQoL).

Based on the HRQoL conceptual model by Wilson and Cleary (1995) (See 1.5), this thesis sought to investigate the impact of protective psychosocial factors (SOC and personality traits) on: (i) self-reported outcome measures of functional health, general health perceptions, and overall quality of life, and (ii) the associations between income and these outcome measures.

2.2 Specific objectives

The specific objectives of the present thesis were to investigate:

(i) The main effects of total annual household income and protective psychosocial factors (SOC and personality traits; separately) on self-reported oral and general health and quality of life outcome measures;

(ii) The interaction effects between total annual household income and protective psychosocial factors (SOC and personality traits; separately) on self-reported oral and general health and quality of life outcome measures; and

(iii) The modifying effects of protective psychosocial factors (SOC and personality traits; separately) on the associations between total annual household income and self-reported oral and general health and quality of life outcome measures.

Specifically, we aimed to investigate whether low-income people with protective psychosocial factors (SOC and personality traits) were able to maintain good health and quality of life outcomes, despite socioeconomic adversities.

2.3 General research questions

This thesis sought to address the gap in literature on the importance of protective psychosocial factors for low-income groups by answering the following research questions:

1. Are protective psychosocial factors (SOC and personality traits) associated with self-reported oral and general health and quality of life?

2. Does the interaction between protective psychosocial factors (SOC and personality traits) and income affect self-reported oral and general health and quality of life?

3. Does the association between income and self-reported oral and general health and quality of life differ by levels of protective psychosocial factors (SOC and personality traits)?

4. Do protective psychosocial factors (SOC and personality traits) modify the association between income and self-reported oral and general health and quality of life?

5. Do low-income individuals with protective psychosocial factors (SOC and personality traits) maintain good self-reported oral and general health and quality of life despite stressors in their lives?

2.4 Thesis structure

This thesis comprises nine chapters. A general introduction is provided in the first chapter. Chapter 2 (the current chapter) describes the aims, outline of the studies, and research questions addressed in this thesis. Chapter 3 provides detailed information on the data, methods, and conceptual framework used for all the studies included in this thesis. Chapters 4 to 8 present the studies included in the present thesis for publication. The outline of these studies is provided in the following section (See 2.4.1). The final chapter (Chapter 9) presents the general discussion and conclusion.

In this thesis, I used the terms "strong" and "weak" to refer to the relative strength of the concept of SOC and personality traits as protective psychosocial factors that can help individuals cope effectively with stress. These terms do not imply any value judgement on the worth of individuals or that they are complicit as victims in some way. This thesis is written using Australian English unless otherwise noted (citations, quotations, or academically coined proper nouns).

2.4.1 Outline of studies

A total of five studies are presented in the thesis. All studies used data from the Dental Care and Oral Health Study (DCOHS), a cross-sectional population-based study in South Australia (2015-2016). Moreover, all studies used a structured conceptual framework for data analysis. A detailed description of the data and methods can be found in the subsequent chapter (See Chapter 3: Data and Methods).

The first study presented in this thesis is entitled "Income and oral and general health-related quality of life: the modifying effect of Sense of coherence, findings of a cross-sectional study". The specific aims of this study were to investigate: (i) the main effects and interaction effects of SOC and income on OHRQoL and HRQoL (measured using the OHIP-14 and EQ-5D-3L; See 3.2.1.3) as functional health status in the Wilson and Cleary's model (Baker et al., 2008; Mayo et al., 2011); and (ii) the modifying effect of strong SOC on the association between low-income and OHRQoL and HRQoL. This study evaluated whether the effect of income on OHRQoL and HRQoL differs by SOC levels. The study, co-authored with Mr Sergio Chrisopoulos, Dr Liana Luzzi, Prof Lisa Jamieson, and Prof David Brennan, is currently under review in the Applied Research in Quality of Life (See Chapter 4).

Following the first study, the study 2 explored the main effects and interaction effects of the "Big Five" personality traits and income on functional health status in Wilson and Cleary's model (OHRQoL and HRQoL; measured using the OHIP-14 and EQ-5D-3L) (Baker et al., 2008; Mayo et al., 2011); and whether higher scores on personality traits modify the associations between low-income and OHRQoL and HRQoL. The second study compared OHRQoL and HRQoL (the OHIP-14 and EQ-5D-3L means, respectively) across income levels and personality traits strata. This study entitled

"Personality traits and income inequalities in self-rated oral and general health" was published online in the European Journal of Oral Sciences (Zakershahrak & Brennan, 2022) (See Chapter 5).

The third study, entitled "Sense of coherence, modifier of the association between income and self-rated oral and general health, a cross-sectional study", is currently under review in the Journal of Public Health Dentistry (co-authored with Mr Sergio Chrisopoulos, Dr Liana Luzzi, Prof Lisa Jamieson, and Prof David Brennan). The objectives of this study were to evaluate the associations (main and interaction effects) between SOC and income self-rated dental and general health (SRDH and SRGH, respectively; measured using single-item global self-ratings; See 3.2.1.3.3), as general health perceptions in Wilson and Cleary's model (Baker et al., 2008). This study investigated whether the association between low income and SRDH and SRGH was modified by strong SOC. Also, this study compared the prevalence of SRDH and SRGH among individuals from different income levels across strong and weak SOC (See Chapter 6).

Study 4, entitled "Effect of personality traits on socioeconomic inequalities in health, a population-based study", is accepted in Community Dentistry and Oral Epidemiology. Following the third study, this study investigated the interaction effects between income and the "Big Five" personality traits with SRDH and SRGH (measured using single-item global self-ratings) and their main effects on these outcomes. Study 4 also evaluated whether the association between low income and SRDH and SRGH was modified by higher scores on personality traits. This study investigated whether the association between different income levels and SRDH and SRGH differed across personality traits strata (See Chapter 7).

The final study is entitled "Can low-income people afford life satisfaction? The modifying effect of personality traits, a cross-sectional study". The objective of this study was to investigate the associations between personality traits and income (main effects and their interaction effects) with life satisfaction as the overall quality of life in Wilson and Cleary's model (1995) (See 3.2.1.3.4); and whether higher scores on personality traits modified the effect of low household income on low life satisfaction. Also, this study investigated whether the association between income and life satisfaction varied across personality trait strata. The final study assessed the effect measure modification on the additive scale by calculating the relative excess risk due to interaction (RERI) and the interaction on multiplicative and additive scales (Knol & VanderWeele, 2012). This study was co-authored with Mr Sergio Chrisopoulos, Dr Liana Luzzi, Dr Dandara Haag, and Prof David Brennan and is currently under review in Current Psychology (See Chapter 8).

2.5 Significance of the study

This thesis evaluated the effect of psychosocial modifiers (SOC and personality traits) on the associations between income and self-reported health and quality of life outcome measures (such as OHRQoL, HRQoL, SRDH, SRGH, and life satisfaction) using statistical analyses of population-based data. Across all five studies, the analysis approach (effect measure modification) provided insights into differences in the associations between income and health and quality of life outcome measures across protective psychosocial factors strata (SOC and personality traits) as the effect modifiers (See Methods) (Knol & VanderWeele, 2012). This way, the findings could point to whether protective psychosocial factors could help low-income groups to cope with health and quality of life challenges.

The findings of this thesis support the potential role of the protective psychosocial factors that could improve oral and general health and quality of life for people on low incomes. The practical implications of these findings could assist health policymakers in directing research and intervention efforts towards areas that improve health and quality of life for low-income groups. This thesis could assist policymakers in designing effective multidimensional interventions to reduce health inequalities that consider the impact of protective psychosocial factors on health and quality of life. Also, this thesis prepares the ground for future longitudinal and experimental studies investigating the effect of protective psychosocial factors on the associations between socioeconomic status and health and quality of life.

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3 Chapter 3: Data and Methods

This thesis comprises five studies that were conducted using the same dataset, similar methodological framework, and sets of models with similar structures. The first part of this chapter focuses on the data used for all studies included in the thesis. The second part of this chapter presents the research methods and design for the models used in these cross-sectional studies.

3.1 Data

This section provides background, design, sampling, data collection and ethics of the Dental Care and Oral Health Study (DCOHS), the dataset that was used for all studies in this thesis.

3.1.1 The Dental Care and Oral Health Study (DCOHS) background

The studies included in this thesis used the data from the Dental Care and Oral Health Study (DCOHS) for the analysis (Song et al., 2020a; Song et al., 2020b). The conceptualisation of this study was based on identifying different oral health outcomes based on different dental care sectors. Brennan et al. (2008) reported that individuals who attended public dental services had poorer oral health outcomes and less access to dental care than those who attended private clinics. It is believed that the quality and value of private dental care are better than public services. However, causal interferences for mechanisms affecting oral health and possible biases in selecting eligible people for public health care are unclear. Therefore, the main aim of DCOHS was to investigate whether different dental care pathways (public or private) contributed to longitudinal changes in oral health outcomes among adults from different SES. DCOHS had three specific objectives: (i) evaluating whether private dental care contributes to better outcomes, (ii) assessing whether higher SES groups benefit more from private dental care to have better outcomes, and (iii) determining why people who are eligible for public dental care often choose private dental care.

This thesis used the baseline data from DCOHS to undertake cross-sectional analyses to address a set of research aims dealing with income and protective psychosocial factors.

3.1.2 The DCOHS design

The DCOHS is a prospective cohort study of a representative sample of South Australian adults aged 18 years and older from 2015 to 2019. A random sample of 12,245 adults living in South Australia in 2015 was selected from the Electoral Roll (a comprehensive sample frame) to participate in the study. The self-reported survey questionnaires were mailed to them with reminders up to three times (Song et al., 2020a; Song et al., 2020b). The collected data consisted of 4,494 responses (completed questionnaires). In the following two years, follow-up observations were conducted on the cohort that participated in the first round. Toward the study's goal, dental care pathways and SES would be used to analyse the changes in oral health outcomes between baseline and follow-up data (as outcome variables). In epidemiology, cohort studies play an important role in demonstrating longitudinal causality between exposures and outcomes, as well as in tracking life stage factors. A two-year period was chosen based on the evidence that approximately 80% of people are likely to use dental services over this period, as reported by Slade et al. (2007). Besides, outcome measures are expected to show measurable changes over a two-year period. DCOHS collected a variety of patient-centred health outcome measures, including clinical dental outcomes, OHRQoL and general health outcome measures, such as HRQoL. Participants' perceptions and interpretations of their health (subjective health) are central to these measures. The DCOHS used standard measures that have been widely used in similar studies, which shows its pragmatic approach.

3.1.3 Sampling procedure

The sample for DCOHS was randomly selected from the South Australian Electoral Roll by the Australian Electoral Commission. The Electoral Roll is a comprehensive sampling frame since voting is compulsory in Australia. The contact details of the adults in the sample were obtained from the Electoral Roll for mailing survey questionnaires, reminder cards, and follow-up materials. DCOHS sample size calculations were conducted (Dupont & Plummer, 1990) based on oral health outcomes estimates from the National Survey of Adult Oral Health (NSAOH) in Australia, with a power of 80% and significance level $\alpha=0.05$. According to NSAOH, $n=200$ is the maximum number needed per group to detect a statistically significant change in OHRQoL. The latest NSAOH data was used for estimating sample response by key study groups (Slade et al., 2007).

To generate a sample size of 3,000 after two years of follow-up, a baseline sample of 12,245 subjects was required, of which 90% of subjects were contactable. There were two important considerations: (i) to collect sufficient numbers of Health Care cardholders after two years of follow-up, to make comparisons between private and public care attendees, and (ii) to collect sufficient numbers of non-cardholder private care attendees from disaggregating by SES.

3.1.4 Data collection

The study used the Total Design Method (Dillman, 1978) to collect data by mailed survey questionnaires from a sample of randomly selected adults from the Electoral Roll. To achieve the appropriate response rate, the first step was to send a primary approach letter, followed by a survey questionnaire, then a reminder card, and finally, up to three follow-up mailings were sent to non-respondents over the period from June to November 2015. A total of 4,494 responses were collected. After adjusting for out-of-scope sample subjects (not residing at the listed address and refusals), the response rate was 44.8%. At the one-year follow-up, a total of 2,980 responses were collected, and at the two-year follow-up, responses were collected from 2,189 participants.

3.1.5 Data preparation

ASCII files were generated by entering responses into a computer and then were manually verified. Name and address details related to subject identifiers were separated from questionnaire data to maintain the confidentiality of responses. A password-protected computer was used to store all computer files, and only the investigators had access to them.

3.1.6 Collected data

Questionnaires collected data on various outcomes, explanatory variables, health and related behaviours, SES and sociodemographic characteristics (such as age, sex, place of birth, education, occupation), and psychosocial variables (See 3.2.1.2.1 and 3.2.1.2.2).

The main outcome variables collected in DCOHS comprise the following valid measures: global self-ratings of oral and general health (See 3.2.1.3.3), self-reported number of teeth (to record tooth loss (Douglass et al., 1991)), wellbeing and life satisfaction (See 3.2.1.3.4), and oral and general health-related quality of life (such as the OHIP-14, See 3.2.1.3.1, and the EuroQol instrument, See 3.2.1.3.2).

The collected main explanatory variables include:

(i) Utilisation of dental services: such as reason, place, time since the last dental visit (See 3.2.1.4.2), and frequency of dental visits in the last 12 months. These items are derived from the National Dental Telephone Interview Survey (Slade et al., 2007).

(ii) SES: such as income, household size, level of education, and occupation. A short version (4-item) of Wright's empirical class typology (classifying individuals based on capital assets' ownership with reference to employment, organisational assets' control in terms of decision-making and management hierarchy, and skill/credential possession) was used to measure social class at the individual level (Krieger et al., 1997; Oakes & Rossi, 2003). Education was assessed using the highest qualification completed (credentials). The total household income (See 3.2.1.1) and equivalized family income (accounting for dependents) were measured at the household level. Also, household social class was measured based on occupation using self-reported occupational class position and stratification of the individual level class position of heads of household (Krieger et al., 1999). The Index of Relative Socio-Economic Advantage/Disadvantage (IRSAD) was used at the community level to assess

SES. IRSAD is a Socio-Economic Index for Areas (SEIFA, developed by the Australian Bureau of Statistics (2006), ranking Australian areas based on SES) representing the average measure of SES of people living in an area.

(iii) Sociodemographic characteristics: such as age, sex, etc.; (See 3.2.1.4.1).

(iv) Psychosocial variables: such as personality traits (See 3.2.1.2.2), sense of coherence (SOC, orientation to life; See 3.2.1.2.1), social support, work-family stress, psychological stress, health self-efficacy, and factors related to dentist-patient relationships. Social support was measured using the Multidimensional Scale of Perceived Social Support, a twelve-item measure evaluating the effectiveness of social support offered by family, friends, and significant others (Dahlem et al., 1991). Work-family stress was evaluated using the Work-Family Conflict Scale, a brief scale (eight items) designed to measure the extent to which work and family duties interfere with one another (Kopelman et al., 1983). Psychological stress was assessed using the Perceived Stress Scale (Cohen et al., 1983) (a fourteen-item instrument measuring the perception of stress) and the Kessler Psychological Distress Scale (Kessler & Mroczek, 1994) (a simple 10-item global measure designed to assess psychological distress). Health self-efficacy was measured with the Perceived Health Competence Scale, which measures individuals' perceived capability to effectively manage their health outcomes, using eight items (Smith et al., 1995). The dentist-patient relationship factors comprise trust in dentists, satisfaction with dental care, and dental fear. Trust in dentists was measured using the Dentist Trust Scale, an eleven-item measure of trust in the dental profession (Armfield et al., 2017). Satisfaction with dental care was assessed with the Dental Care Satisfaction scale (Stewart & Spencer, 2005), a measure of patient satisfaction with the care they received at their last dental visit, using nine items. Dental fear was collected by asking, "Do you feel afraid or distressed when going to the dentist?" as used in Australian national surveys (Armfield et al., 2009).

3.1.7 Ethics and funding

Ethics approval was granted by the University of Adelaide Human Research Ethics Committee (H-288-2011) (Song et al., 2020a; Song et al., 2020b). The Helsinki declaration for ethical standards was followed throughout the study. The act of completing and returning the questionnaires by participants was considered as informed consent, given the nature of the study design.

Funding for this study was provided by a National Health and Medical Research Council CRE grant (1031310) (Song et al., 2020a; Song et al., 2020b). The funding source was not involved in the design, implementation, analysis, or interpretation of the data collected from this study.

3.2 Methods

The five studies in this thesis were analysed using a structured conceptual approach based on four models. I expanded these models in the last subsection (See 3.2.4). For each study, detailed information on the variables used in these models is provided in subsection 3.2.1. In subsection 3.2.3 and its related parts, I explained the analytical approaches used for each study.

3.2.1 Variables

A detailed description of the variables used in the five studies of this thesis is given in this section. All studies used a similar structured conceptual framework. The same exposure variable and sets of covariates were used across all studies. The protective psychosocial factors were used as effect modifiers (SOC and personality traits).

3.2.1.1 Exposure

The exposure variable for all studies was the total household income before tax (including any salaries, pensions, allowances, benefits, et cetera from all persons in the household). The total household gross income was collected in DCOHS in ten categories (in Australian Dollars) by asking the question, "Which category does your total household income (before tax) fall into?". The categories comprised: Less than $20,000, $20,001 to $40,000, $40,001 to $60,000, $60,001 to $80,000, $80,001 to $100,000, $100,001 to $120,000, $120,001 to $140,000, $140,001 to $160,000, $160,001 to $180,000, and More than $180,000.

For all studies except study five, a distributional approach was used to categorise income into three approximately equal-sized categories (approximate tertiles) of 0 to $40,000 for low income, $40,001 to $100,000 for middle income, and more than $100,000 for high income. In study five, income was categorised into two categories of low income ($40,000 and less than that) and high income (more than $40,000).

3.2.1.2 Effect modifiers

The effect modifier for studies one and three was SOC, measured using the three-item SOC (SOC-3) scale. The effect modifiers for studies two, four and five were the "Big Five" personality traits, measured using the Ten-Item Personality Inventory (TIPI). Throughout this thesis, the terms "strong" and "weak" were used to refer to the relative strength of the concept of SOC and personality traits as protective psychosocial factors. In using these terms, no value judgement was made on individuals, nor were they interpreted to suggest that they were complicit as victims in some way.

3.2.1.2.1 Three-item scale sense of coherence (SOC-3)

The three-item SOC-3 scale is a short, valid, fast and simplified instrument to measure SOC in large surveys (Chiesi et al., 2018) developed by Lundberg & Peck (1995). It was derived from Antonovsky's original SOC instruments (SOC-13 and SOC-21). Each dimension of SOC is evaluated by one item in SOC-3. Comprehensibility is assessed by asking, "Do you usually feel that the things that happen to you in your life are hard to understand?". Manageability is assessed by asking, "Do you usually see solutions to problems and difficulties that other people find hopeless?". Meaningfulness is assessed by asking, "Do you usually feel that your daily life is a source of personal satisfaction?". The responses are in a 3-point format ("Yes, usually", "Yes, sometimes", and "No"). The responses to the meaningfulness and manageability items ranged from 0 to 2 (0=Yes, usually, 1=Yes, sometimes, and 2=No). As recommended by Lundberg & Peck (1994), the responses to the comprehensibility item were reverse-scored to match the responses to the other two items. The total index score was calculated by summing the scores of three items, ranging from 0 to 6. The higher scores represented lower SOC (weak coherence). As suggested by Lundberg and Peck (1994), the total index scores were divided into two categories, strong (total scores 0 to 2) and weak (total scores 3 to 6).

3.2.1.2.2 The Ten-Item Personality Inventory (TIPI)

The TIPI is a brief self-rated instrument developed by Gosling (2003) to evaluate the "Big Five" personality traits in a short time (60 seconds). The "Big Five" personality traits are extraversion (being sociable and a desire to interact with others), agreeableness (being empathetic, trustworthy and helpful), conscientiousness (self-discipline, being reliable, responsible and detail-oriented), emotional stability (the opposite of neuroticism, being balanced, calm, and stable in stressful situations), and openness (being creative, intellectually curious, open-minded and imaginative). Test-retest reliability of TIPI is adequate, and it shows acceptable psychometric validity (Gosling et al., 2003; Nunes et al., 2018). In TIPI, each trait is evaluated using a standard item (reflecting a positive pole) and a reverse-scored item (reflecting a negative pole). Each item is reported on a 7-point Likert scale (from 1= Disagree Strongly to 7= Agree Strongly). As recommended by Gosling (2003), the responses to the reversed items were recoded to match the responses to the standard items. The average of the standard and recoded reverse-scored items related to each trait was used to calculate each trait's score, ranging from 1 to 7. An individual who scored higher on a trait was more likely to exhibit that trait. Each trait's scores were used to determine where respondents fell on that trait's spectrum. Each trait's scores (measured using TIPI scale scores) were divided into two categories of lower TIPI (less than 5 representing disagree) and higher TIPI (5 to 7 representing agree) using a conceptual approach; splitting the scale based on a score equivalent to being "agree" or higher (on average).

In the discussion, I explained the rationale for the conceptual approach used for personality traits (See 9.2).

3.2.1.3 Outcome variables

The outcome variables followed the order of Wilson and Cleary's model (1995) across studies from functional health to general health perceptions and overall quality of life. The outcome variables for studies one and two were HRQoL and OHRQoL, measured using The European Quality of Life indicator or EuroQol (EQ-5D-3L) and the Oral Health Impact Profile (OHIP-14). The outcome variables for studies three and four were self-rated dental and general health (SRDH and SRGH, respectively), measured using single-item global ratings. Finally, the outcome variable for study five was the overall quality of life, measured using the Satisfaction With Life Scale (SWLS).

3.2.1.3.1 OHIP-14

The OHIP-14 is an oral health instrument measuring self-reported OHRQoL in seven dimensions (functional limitation, physical pain, psychological discomfort, physical, psychological and social disability, and handicap) using 14 items. Slade and Spencer developed it as a shortened version of OHIP-49 (Slade, 1997), which is based on Locker's conceptual model of oral health. The OHIP-14, the most commonly used OHRQoL measure, is a valid instrument with high reliability (Slade, 1997). The OHIP-14 is conceptually considered as functional health in Wilson and Cleary's model (Baker et al., 2008). Responses are reported on a five-point Likert-type scale (0= "Never", 1= "Hardly ever", 2= "Occasionally", 3= "Fairly often", and 4= "Very often"). The total score was calculated by summing the scores of fourteen items, ranging from 0 to 56. Respondents with higher scores have poorer OHRQoL.

3.2.1.3.2 EQ-5D-3L

The EQ-5D is a standardised generic instrument measuring HRQoL in five dimensions of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The EQ-5D-3L has a 3-level response format for each dimension ("No problems", "Some problems", and "Extreme problems") (Van Reenen et al., 2018). A recent psychometric validation of the EQ-5D-3L in a general Australian population (using DCOHS) demonstrated good discrimination between health states and acceptable reliability (Zakershahrak et al., 2022). In Wilson and Cleary's model, the EQ-5D is conceptually considered as functional health (Mayo et al., 2011). To be consistent with the other outcome variable (the OHIP-14) as the impact score in studies one and two, responses were coded as 0=No problems, 1=Some problems, and 2=Extreme problems (Brennan, 2013). The total score was calculated by summing the scores of five dimensions, ranging from 0 to 10. Respondents with no problems were assigned a score of zero. Those with higher scores have poorer HRQoL.

3.2.1.3.3 SRDH and SRGH

Single-item global self-ratings are one of the most commonly used measures to assess oral and general health status. They are non-clinical measures that have been used to predict mortality and morbidity. They can also be used for high-risk groups' screening and as clinical trials' endpoints (Fayers & Sprangers, 2002). Based on Wilson and Cleary's model (1995), SRDH and SRGH are conceptually considered as general health perceptions (Baker et al., 2008). SRDH was assessed by asking, "How would you rate your dental health?". SRGH was assessed by asking, "How would you rate your general health?". These single-item global ratings are valid measures that provide subjective perceptions of oral and general health. The responses are reported on 5-point Likert scales, comprising "Excellent", "Very good", "Good", "Poor", and "Very poor". As suggested by previous studies (Cislaghi & Cislaghi, 2019; Teusner et al., 2014), the respondents were dichotomised into those who rated their oral and general health as "Excellent" to "Good" and those who rated their oral and general health as "Poor" to "Very poor".

3.2.1.3.4 SWLS

The SWLS is a valid and reliable scale measuring overall satisfaction with life using five statements (Bendayan et al., 2013) developed by Diener et al. (1985). Based on Wilson and Cleary's model (1995), the overall quality of life was measured by SWLS. Responses are reported using a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree) (Bendayan et al., 2013; Diener et al., 1985). The total score was calculated by summing the scores of five items, ranging from 5 to 25, where a score of 15 shows a neutral SWLS. Respondents with higher scores have higher life satisfaction (overall quality of life). Considering the non-normal distribution of SWLS scores among respondents included in study five's analyses, total scores were divided (St John et al., 2021) into two categories: those who were satisfied (scores 16 or higher) and those who were dissatisfied with their life (scores 5-15).

3.2.1.4 Covariates

In all studies of this thesis, the same covariates were added to the models in consecutive blocks of conceptually related variables to address the different dimensions of sociodemographic characteristics and health behaviours. The sociodemographic characteristics comprised age, sex, the main language spoken at home and birthplace. The health behaviour variables comprised dental insurance, smoking status, daily tooth brushing, and last dental visit. I described these variables in the following subsections (See 3.2.1.4.1 and 3.2.1.4.2).

The health behaviours covariates were selected based on the general concept of health behaviours. These variables are more likely to cluster or bundle together rather than occur individually (Alzahrani et al., 2014; Sanders et al., 2005). The health behaviours covariates represent the following conceptual factors: (i) preventive behaviours such as daily tooth brushing frequency, (ii) utilisation of health care services such as the last dental visit, (iii) enabling factors such as having cover for dental insurance, and (iv) risky behaviours such as smoking.

3.2.1.4.1 Sociodemographic characteristics

Age was collected as continuous data in DCOHS by asking the respondents to write their "year of birth". Across all studies, to produce an approximately equal distribution, it was categorised into three age groups: 18 to 45 years old, 46 to 60 years old, and 61 years old and more.

The main language spoken at home was collected by asking, "What is the main language you speak at home?". The options were English and other. In the case of other languages spoken at home, respondents were asked to specify them. In all studies, respondents were categorised as English speakers and those who spoke other languages.

The birthplace was collected by asking, "In which country were you born?" with Australia and other countries as options. Respondents were asked to specify their country of birth if the response was "other country". For all studies, birthplace was categorised into two groups: those who were born in Australia and those who were born in other countries.

3.2.1.4.2 Health behaviour variables

For dental insurance, respondents were asked, "What best describes your private health insurance status?" after they chose private health insurance. According to the Australian health system, the respondents who selected the options "Combined hospital & ancillary/extras cover" or "Ancillary/extras only cover" had the cover for dental insurance. In all studies, this covariate was dichotomised into those who had dental insurance and those who did not have it.

Smoking status was collected by asking, "Which of these statements best describe your cigarette smoking status?". The options were "I smoke daily", "I smoke occasionally", "I do not smoke now but I used to", and "I have never smoked". Smoking status was classified as current smokers, former smokers and non-smokers across all studies.

For daily tooth brushing, the tooth brushing habits section in DCOHS was used. Within this section, participants were asked, "In the last week, how many times did you brush your teeth?". Later, the frequency of daily tooth brushing was derived from the responses. In all studies, respondents were classified as those who brushed their teeth twice a day or more and those who brushed less than that.

The last dental visit was collected by asking, "When was your last visit to a dental professional?" (includes dentist, dental specialist, oral health therapist, dental hygienist, dental therapist, dental technician, denturist or dental prosthetist). The six ordinal levels of the options were "Less than 12 months ago", "1 to less than two years ago", "two to less than five years ago", "five to less than ten years ago", "ten years or more" and "Never attended". Respondents were dichotomised as individuals who visited the dentist less than a year ago and others with a previous dental visit one year ago or later in all studies.

3.2.2 Final sample

In all studies, only respondents who provided full answers to all items of questions related to the exposure (income), the effect modifiers (psychosocial factors) and outcome variables were included in the statistical analyses. In studies two to five, Poisson regression excluded respondents with missing data in any covariate. Thus, the final sample size in each study differed from the DCOHS. Therefore, in each study, respondents included in the final sample were compared to the excluded respondents due to missing data to explore the potential bias. Also, the representativeness of the final sample was explored by comparing it to census data.

3.2.3 Statistical analysis

For the studies included in this thesis, two analytical approaches were used (See 3.2.3.1 and 3.2.3.2): (i) factorial ANOVA (general linear model) and (ii) multivariable Poisson regression (generalised linear model with a log-Poisson link and robust error). In all studies, the data were weighted based on the Estimated Resident Population from the Australian Bureau of Statistics to be representative of the age and sex distribution of South Australian adults.

3.2.3.1 Factorial ANOVA (general linear model)

In study one and study two, factorial ANOVA models (general linear models) were used to investigate: (i) the associations (main effects) between protective psychosocial factors as effect modifiers (SOC for study one; personality trait dimensions for study two) and household income levels (as exposure variable); and (ii) the interaction effects between protective psychosocial factors (SOC for study one; personality trait dimensions for study two) and household income with each outcome separately (OHRQoL and HRQoL, measured using the OHIP-14 and the EQ-5D-3L, respectively).

3.2.3.2 Multivariable Poisson regression (generalised linear model with a log-Poisson link and robust error)

For study three and study four, multivariable Poisson regression was applied to investigate the associations (main effects) between protective psychosocial factors as effect modifiers (SOC for study three; personality trait dimensions for study four) and household income levels (as exposure variable) and their interaction effects with each outcome separately (general health perceptions, measured using SRDH and SRGH).

In study five, multivariable Poisson regressions were also applied to investigate the associations (main effects) between personality trait dimensions (effect modifiers) and household income levels (exposure variable) and their interaction effects with the overall quality of life, measured using SWLS (outcome). Also, study five employed an additional approach to assess the direction of effect modification by calculating the Relative Excess Risk due to Interaction (RERI) (Knol & VanderWeele, 2012). Calculation of the RERI was performed using generalised linear models (with a log-Poisson link and robust errors). The RERI was applied to estimate the prevalence ratios of SWLS across different levels of household income and each personality trait.

3.2.4 Models

The structured conceptual framework for model building in all studies in this thesis is explained in this section. All studies in this thesis employed the same strategy, which was to investigate the associations between income and protective psychosocial factors (SOC and personality traits) in four multivariable models using different statistical analyses (for statistical analysis, See 3.2.3). These models comprised an unadjusted interaction model (the simplest interaction model) and then a structured set of adjusted models to control for putative covariates, which were added in conceptual blocks of sociodemographic characteristics and health behaviour variables. The conceptual basis for building and analysing multivariate models was based on the inter-relationships between the variables (See 3.2.1.4).

The first model (crude model) was designed to evaluate unadjusted associations (main effects) between income categories and protective psychosocial factors (SOC and personality traits) and their interaction effects with each study's outcome variables separately (See 3.2.1.3). Then, conceptually related covariates (sociodemographic characteristics and health behaviours; See 3.2.1.4) were added to the analysis in successive blocks using a structured approach (Victora et al., 1997) to investigate the adjusted main and interaction effects. Therefore, in models 2 to 4, the analyses from model 1 (the simple crude model) were adjusted for different sets of conceptually related covariates that were added in the subsequent steps. In the second model (model 2), sex and age groups were added to control for their effects. The third model (model 3) included all sociodemographic characteristics comprising age, sex, the main language spoken at home and birthplace to adjust for their effects. The last model was the fully adjusted model (model 4). This model included all covariates comprising sociodemographic characteristics (age, sex, the main language spoken at home and birthplace) and health behaviour variables (dental insurance, smoking status, daily tooth brushing and last dental visit) to control for their effects (See Figure 3.1).

In each study, these four models evaluated: (i) the main effect and the interaction effects between the exposure (income) and effect modifiers (psychosocial factors) for outcome variables (separately), along with (ii) whether effect modifiers (psychosocial factors) modified the associations between the exposure (income) and outcome variables (separately) (See Figure 3.2, Figure 3.3, Figure 3.4).

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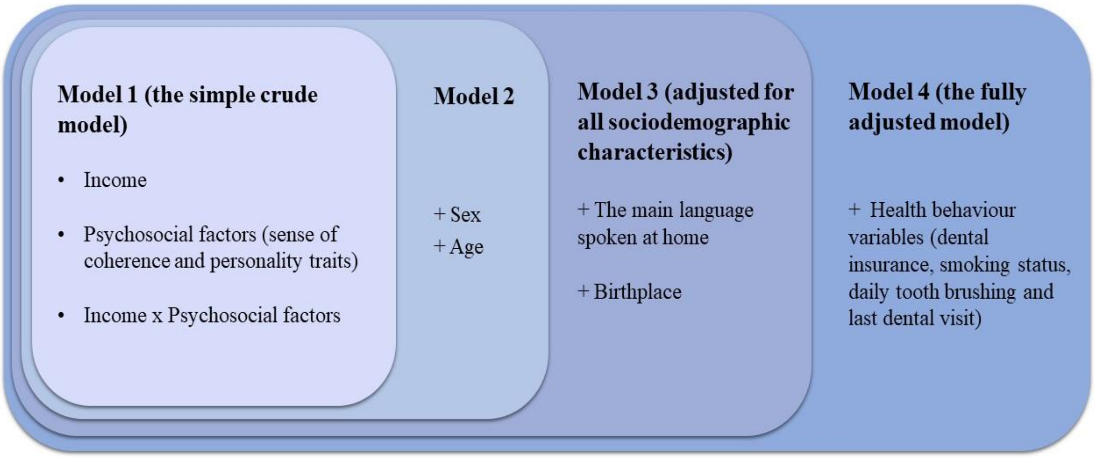

Figure 3.1 The structure of models across all studies of this thesis

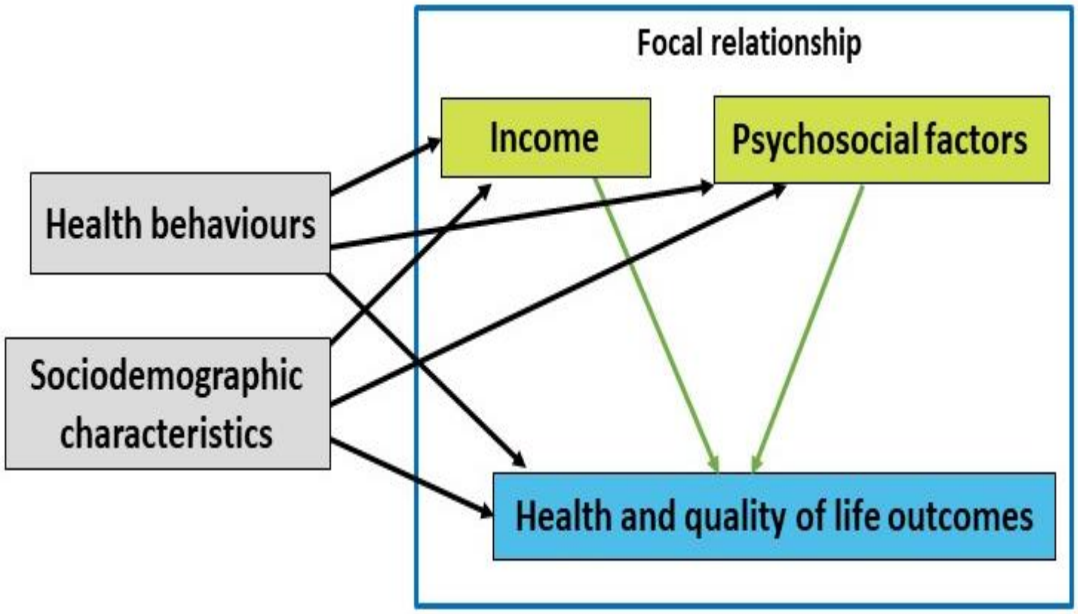

Figure 3.2 Directed Acyclic Diagram (DAG) with the focal relationships between the protective psychosocial factors (sense of coherence and personality traits) and total household income as the main exposures and health and quality of life outcome measures (the outcome)

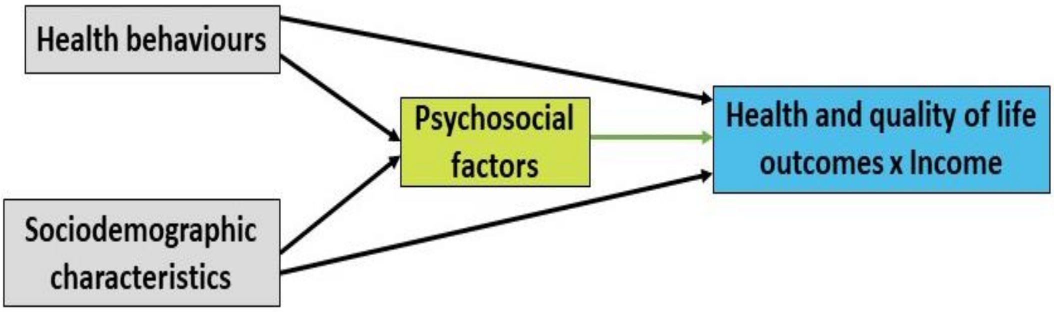

Figure 3.3 Direct Acyclic Diagram (DAG) with the interaction effect between the protective psychosocial factors (sense of coherence and personality traits) and total household income as the main exposures with health and quality of life outcome measures (the outcome)

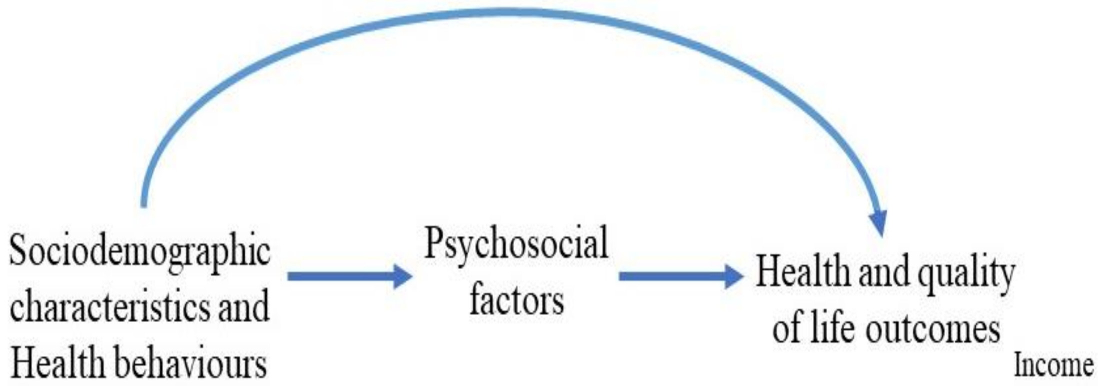

Figure 3.4Interaction Directed Acyclic Diagram (IDAG) of the interaction effect between the protective psychosocial factors (sense of coherence and personality traits) and total household income as the main exposures with health and quality of life outcome measures (the outcome)

4 Chapter 4: Income and oral and general health-related quality of life: the modifying effect of Sense of coherence, findings of a cross-sectional study

4.1 Highlights

- The main effects of sense of coherence (SOC) and income and their interaction effects on oral and general health-related quality of life (OHRQoL and HRQoL, respectively) were found.

- Strong SOC (i.e., high coherence in terms of the relative strength of the concept of SOC) modified the associations between low-income and poor OHRQoL and HRQoL. Low-income individuals with strong SOC had similar OHRQoL and HRQoL to those from high and middle-income levels but weak SOC.

- Findings suggested SOC had a protective effect for individuals from all income levels in terms of OHRQoL and HRQoL. However, having strong SOC was more beneficial for low-income individuals than high-income people in terms of possible health gains in OHRQoL and HRQoL.

4.2 Statement of Authorship

Statement of Authorship

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Principal Author

Name of Principal Author (Candidate)	Mehrsa Zakershahrak		
Contribution to the Paper	Conceptualisation, design and implementation of research methodology Data analysis, and model design Manuscript writing – original draft preparation Editing and revisions Performing duties as corresponding author		
Overall percentage (%)	75%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	22 August 2022

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate in include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Study 1: Income and oral and general health-related quality of life: the modifying effect of Sense of coherence, findings of a cross-sectional study

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Abstract

Objectives: To investigate whether a strong sense of coherence (SOC) modifies the association between low-income and oral and general health-related quality of life (OHRQoL and HRQoL, respectively) among a South Australian population sample; and to explore the main and interaction effects of income and SOC on OHRQoL and HRQoL.

Methods: Baseline data from the Dental Care and Oral Health Study (DCOHS, a South Australian representative study, 2015-2016) was used for cross-sectional analysis (n=3,786). Four multivariable factorial ANOVA models were applied to assess the effect measure modification, main effects, and interaction of income and SOC on OHRQoL (measured using the OHIP-14) and HRQoL (measured using the EQ-5D-3L).

Results: Income and SOC had small main effects on OHRQoL. Income had a small effect, and SOC had an intermediate effect on HRQoL, meaning that individuals with strong SOC had better OHRQoL and HRQoL in all income categories. Also, high-income participants had better OHRQoL and HRQoL. The interaction between income and SOC was statistically significant on HRQoL. Among participants from low-income group, those with strong SOC had better OHRQoL (mean=8.8, 95% CI[7.9, 9.7]) and HRQoL (mean=1.1, 95% CI[1.0, 1.3]) than others with weak SOC OHIP-14 mean=12.7, 95% CI[11.7, 13.6]) and (EQ-5D-3L mean=2.0, 95% CI[1.9, 2.2].

Conclusion: The findings showed the main effects and interaction between SOC and income on OHRQoL and HRQoL. Income had different effects on OHRQoL and HRQoL depending on whether SOC was strong or weak. Findings suggested that strong SOC modified the association between low-income and OHRQoL and HRQoL.

Keywords: Sense of Coherence, oral health, socioeconomic status, health-related quality of life

Introduction

Many studies have shown income gradients in health (Bernabé et al., 2015; Sabbah et al., 2007). However, it is unclear how some people who face income-related health adversity can escape this cycle and have good health. Since low-income individuals are faced with many barriers and stressors that impact their health, psychosocial factors enhancing their coping abilities could be beneficial for them (Atal & Cheng, 2016; Chen et al., 2011; Mizuta et al., 2020). Researchers use Aaron Antonovsky's salutogenic theory to explain why some individuals are more resilient to diseases, are able to maintain good health, can thrive under adverse conditions, and cope with severe stressors (Antonovsky, 1979, 1987, 1995). Sense of coherence, as this theory's central concept, reflects a person's outlook on life and the ability to respond to strained conditions (Antonovsky, 1993). People with strong SOC find life more manageable, structured, meaningful and comprehensible. SOC has three components: comprehensibility, manageability, and meaningfulness (Antonovsky, 1987, 1993). Those with a strong SOC also have better health outcomes (Eriksson & Lindström, 2006) and coping capacity for daily stressors (Super et al., 2016) than others. An individuals' SOC is influenced by their mindset, performance and behaviours, which help them find and use resources to improve their well-being, health and quality of life (Eriksson & Lindström, 2006). The other component of the salutogenic theory is general resistance resources (GRRs), which are those life experiences that shape SOC (such as social support, intellectual, physical, cultural and financial factors, and coping strategies) (Antonovsky, 1979, 1987; Horsburgh & Ferguson, 2012; Idan et al., 2017). GRRs facilitate recovery from diseases faster by choosing healthy habits (e.g., healthy eating, physical activity, regular check-ups) and avoiding unhealthy behaviours (e.g., smoking, unhealthy lifestyle, excessive drinking) (Savolainen et al., 2009).

While low-income people face many challenges and stressors in their lives, some "beat the odds" and manage to have better health through strong SOC (Mizuta et al., 2020; Speirs et al., 2016). Strong SOC enables low-income families to adopt healthy behaviours regardless of the limited resources available (Speirs et al., 2016). SOC could efficiently promote dental health, especially among those individuals living below the poverty line (Mizuta et al., 2020). The association between the guardians' SOC and caries prevalence among low-income children has been reported (Mizuta et al., 2020). Also, SOC was associated with adults' better oral health behaviours, independent of socioeconomic status (SES) or demographic characteristics (Bernabé et al., 2009). While financial factors and SES are considered as essential GRRs and manageability resources, they are not the only factors contributing to people's resilience in socioeconomic adversity related to health and quality of life (such as income-health disparity). People's SOC was found to be different according to their healthy lifestyle choices regardless of their SES (Wainwright et al., 2007). It should be noted that SOC is explained by other factors that go beyond income and SES. These include hereditary, environmental, financial, knowledge, religion, ritualistic beliefs, healthy behaviours, mindset, and social factors (Antonovsky, 1979, 1987; Horsburgh & Ferguson, 2012; Idan et al., 2017; Super et al., 2016). According to a study of unemployed migrant women, strong SOC was related to the meaningfulness of what they had gone through and GRRs such as social support, religion, and exchanging empowerment stories (Slootjes et al., 2017).

The association between strong SOC with oral and general health-promoting behaviours, OHRQoL and HRQoL, has been reported (Flensborg-Madsen et al., 2005; Nammontri et al., 2013; Savolainen et al., 2009). Also, the modifying effect (previously known as the moderating effect (Knol & VanderWeele, 2012)) of SOC on health (Feldt, 2002) and the interaction between SOC and SES on oral health (among low-income groups) (Mizuta et al., 2020) have been reported. Effect modification refers to different effects of the exposure on the outcome variable across strata of another exposure (VanderWeele, 2009), while interaction refers to the specific combined effect of both exposures on the outcome variable that neither exposure alone can explain (VanderWeele, 2009).

A study that investigated factors related to coping with health challenges in Cameroon found that the coping skills of people living in poverty (determined mainly by low income) against diseases were strongly related to the individual's dispositional factors (such as SOC) (Makoge et al., 2019). Interestingly, their coping was not associated with income or social factors (Makoge et al., 2019). However, the effect of income on oral and general health-related quality of life (OHRQoL and HRQoL) is evident (Brennan & Spencer, 2014; Sun et al., 2018). Therefore, it will be beneficial to identify the factors associated with coping abilities related to income-health disparities among low-income individuals, aiming to address such disparities. Consequently, further investigation into the role of SOC as a possible modifier of the association between low-income and OHRQoL and HRQoL is required. Thus, this study aimed to estimate: First, the main effects and interaction between income and SOC on OHRQoL and HRQoL separately; Second, whether the association between low-income and OHRQoL and HRQoL is modified by strong SOC among a South Australian population sample. The hypotheses were: 1- SOC is associated with better OHRQoL and HRQoL; 2- there are interaction effects (joint effects) between SOC and income with OHRQoL and HRQoL; and 3- strong SOC modifies the association between low income and OHRQoL and HRQoL. We hypothesized that in participants from low-income groups, those with strong SOC have better OHRQoL and HRQoL.

Methods

The baseline data of the Dental Care and Oral Health Study (DCOHS) were used for cross-sectional analysis. DCOHS is a South Australian survey collected in 2015-2016. Mail surveys were sent to 12,245 randomly selected individuals from the Electoral Roll (a comprehensive sample frame), aged 18 years old and above. A total of 4,494 responses were received (response rate=44.8%). Ethics approval was provided by the University of Adelaide Human Research Ethics Committee (H-288-2011) (Song et al., 2020a; Song et al., 2020b).

Outcome variables were the Oral Health Impact Profile (OHIP-14) to assess OHRQoL and the European Quality of Life indicator or EuroQol (EQ-5D) to evaluate HRQoL. The OHIP-14 is an oral health instrument that reflects patients' oral health and the social impacts of their oral health on their OHRQoL in seven dimensions (functional limitation, physical pain, psychological discomfort, physical, psychological and social disability, and handicap) using 14 items (Slade, 1997). This OHRQoL measure has been validated in Australia with high reliability (Slade, 1997). Responses were coded using a Likert-type scale (0=never to 4=very often) with summed scores ranging from 0 to 56 (higher scores reflecting poorer OHRQoL). The EQ-5D is a self-reported instrument measuring the health status in five dimensions of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression according to a 3-level response (EQ-5D-3L) (Van Reenen et al., 2018). Recent validation of EQ-5D-3L has been conducted in a general Australian population (using DCOHS), showing acceptable reliability and good discrimination between health states (Zakershahrak et al., 2022). To be consistent with the OHIP-14 (as an impact score), the EQ-5D-3L was rescaled with answers coded 0=No problems to 2=Extreme problems (Brennan, 2013). Therefore, those with no problems were anchored at zero scores with summed scores ranging from 0 to 10. The higher summed scores indicate poor HRQoL.

The explanatory variable was the total household income, which was collected in 10 categories (<$20,000 to >$180,000 in Australian Dollars). Income was coded into approximate tertiles (approximately equal sized groups): ≤$40,000, more than $40,000 to $100,000 and >$100,000.

The effect modifier was the three-item scale SOC (SOC-3) (Lundberg & Peck, 1995), which is a validated and fast version of the SOC instrument for large questionnaires (Chiesi et al., 2018). Each item is designed to evaluate one of SOC's dimensions. The answers to meaningfulness and manageability were scored as Yes, usually=0, Yes, sometimes=1, and No=2. Responses to comprehensibility were reverse-coded to match the order of the other two dimensions' answers. The total index score was calculated (0 to 6), where higher scores equate to lower coherence (weak SOC). The total scores were dichotomised into strong (0 to 2) and weak (3 to 6) based on previous research (Lundberg & Peck, 1994).

Other variables included in the models to adjust for their effects comprised: demographics (age, sex, place of birth and main language spoken at home) and health behaviours (dental insurance, smoking status, tooth brushing, and last dental visit). Age was coded into three approximately equal-sized age groups (approximate tertiles): 18-45, 46-60, and 61 years and older. The place of birth was grouped as Australia or other countries. Dental insurance was dichotomised as insured and uninsured. The language was coded as those who mainly spoke English and those who mainly spoke other languages at home. Smoking status was classified into three groups: current smokers, former smokers and those who never smoked. Tooth brushing was categorised as participants who brushed twice a day or more and others who brushed their teeth less than twice a day. The last dental visit was coded as individuals who visited the dentist less than 12 months ago or 12 months ago and more.

A total of 3,786 respondents, with complete answers to outcome variables (OHIP-14 and EQ-5D-3L), effect modifier (SOC) and explanatory variable (income), were included in the analysis. As there may be response bias (difference between dropout individuals' responses and respondents), the final sample was compared with participants with missing responses. Also, a comparison between the final study sample (n=3,786) and census data was conducted to assess the representativeness.

First, skewness and kurtosis of the outcome variables were calculated to verify assumptions of the factorial ANOVA (which are applied to the residual values). The Estimated Resident Population from the Australian Bureau of Statistics were used to weight the responses to be representative of the age and sex distribution of South Australians. Four factorial ANOVA models (general linear models) were designed to evaluate the main effect and interaction between different levels of income and SOC on the OHIP-14 and, later on the EQ-5D-3L (each outcome was analysed and modelled separately). The analyses comprised the simplest interaction between SOC and income groups (model 1), followed by a structured approach (models 2 to 4) that included putative confounders in consecutive blocks of conceptually related variables (demographics and health behaviour variables). Therefore, models 2 to 4 adjusted for different sets of variables (Model 2: sex and age, Model 3: all demographics, Model 4: all demographics and health behaviour variables). These models evaluated: 1-whether the associations between the OHIP-14 and the EQ-5D-3L with income were modified by strong SOC, and 2- the main effect and the interaction between SOC and income on each health outcome (Figures 3-5). The partial Eta-squared (partial η^2, as the most common standardised effect size statistic for factorial ANOVA) of the main effect and interaction between SOC and income adjusted for different covariates were estimated using general linear models. Based on the benchmark literature (Richardson, 2011), the partial η^2 greater than 0.0099 and lower than 0.0588 was interpreted as a small effect size, and between 0.0588 to 0.1379 was considered an intermediate effect size. Values lower than 0.0099 were indicated as having no effect.

The analyses were repeated using transformed outcomes (log) to correct any skewness (if existing) that may have affected the result. Statistical analyses were performed using SPSS version 28 (IBM Corp.) with 95% confidence intervals.

Result

Participants with complete responses (complete answers to all items) to the OHIP-14, EQ-5D-3L, SOC and income were analysed (n=3,786). Due to the possibility of response bias, the final sample was compared with missing cases (Table S1). Both samples had similar compositions with differences in dental insurance and age groups; the missing cases were more likely to be older and without dental insurance. However, the differences were not statistically significant.

To evaluate the representativeness of the final sample, we compared it with the population data from the South Australian census (Table S2). The composition of the final sample and census data was similar, with slight variations in place of birth, age groups and income groups. In the final sample, respondents were mostly born in Australia, younger, and had a higher percentage of high-income households.

Just over half of the sample were female (55.7%), aged 61 years and older (35.8%, mean age=52.9), had a strong SOC (71.4%), had dental insurance (68.7%), were in the middle-income threshold (41.2%), and had never smoked (54.5%) (Table 1). The mean (SD) score for the OHIP-14 was 6.3 (8.6) and for the EQ-5D-3L was 0.9 (1.3). The lowest means for the OHIP-14 and the EQ-5D-3L (better OHRQoL and HRQoL) were observed in those from the high-income level, strong SOC, the age group 18-45 years old, the Australian-born, dentally insured adults and non-smokers. Also, the OHIP-14 and the EQ-5D-3L had kurtosis of 5.32 and 3.53, respectively. The OHIP-14's skewness was 2.17, and the EQ-5D-3L's was 1.81.

The main effects of income and SOC on the OHIP-14 were statistically significant in all models (Table 2). The magnitude of effect sizes of SOC and income on the OHIP-14 was small (0.0099<partial η^2<0.0588) across all models. There was a statistically significant interaction between SOC and income on the OHIP-14 in all models (model 1, $F(2, 3780) = 6.312$, $p<0.01$, partial $\eta^2 = 0.003$, Adjusted $R^2 = 0.086$); model 2 ($F(2, 3777) = 5.396$, $p<0.01$, partial $\eta^2 = 0.003$, Adjusted $R^2 = 0.090$); model 3 ($F(2, 3686) = 5.732$, $p<0.01$, partial $\eta^2 = 0.003$, Adjusted $R^2 = 0.094$); and model 4 ($F(2, 3545) = 4.892$, $p<0.01$, partial $\eta^2 = 0.003$, Adjusted $R^2 = 0.0141$).

Income and SOC had statistically significant main effects on the general health outcome (all models). The magnitude of effect sizes of SOC (model 2) and income (model 1) on the EQ-5D-3L was intermediate (0.0588<partial η2<0.1379). The effect size of SOC in models 1, 3 and 4 and income in models 2 to 4 on general health outcome was small. The interaction between income and SOC on the EQ-5D-3L (Table 3) was statistically significant in all models (model 1, $F(2, 3780) = 5.540$, $p<0.01$, partial $\eta^2 = 0.003$, Adjusted $R^2 = 0.156$); model 2, $F(2, 3777) = 10.166$, $p<0.001$, partial $\eta^2 = 0.005$, Adjusted R^2 = 0.185); model 3, $F(2, 3686) = 9.697$, $p<0.001$, partial $\eta^2 = 0.005$, Adjusted R^2 = 0.184); model 4, $F(2, 3545) = 9.319$, $p<0.001$, partial $\eta^2 = 0.005$, Adjusted R^2 = 0.190).

Figure 1 demonstrates the effect modification of SOC on the OHIP-14 at different levels of income in model 4 with a statistically significant interaction. OHRQoL of those with low-income and strong SOC (mean=8.8, 95% CI[7.9, 9.7]) were slightly better than those at middle income (mean=8.9, 95% CI[8.0, 9.8]) and were comparable to those at high-income level (mean=8.1, 95% CI[6.9, 9.3]) with weak SOC. Figure 2 shows the effect modification of SOC on the EQ-5D-3L in model 4 (with statistically significant interaction). The HRQoL of low-income respondents with strong SOC (mean=1.1, 95% CI[1.0, 1.3]) were comparable to high income individuals with weak SOC (mean=1.0, 95% CI[0.9, 1.2]) and better than those at middle income with weak SOC (mean=1.4, 95% CI[1.2, 1.5]).

To explore the impact of possible violations of the normality assumptions, the analyses were repeated with log-transformed outcome variables. The results were similar to those obtained using the original data.

Discussion

The study aimed to test the hypotheses as follows: SOC is associated with better OHRQoL and HRQoL; SOC and income have interaction effects with OHRQoL and HRQoL; the modifying effect of strong SOC in the association between low income and OHRQoL and HRQoL; and among low-income participants, those with strong SOC have better OHRQoL and HRQoL. The findings showed that strong SOC was associated with better OHRQoL and HRQoL across all models. Interactions between SOC and income on OHRQoL and HRQoL were observed in all models. The findings suggest a modifying effect of strong SOC on the associations between income and OHRQoL and HRQoL, with a higher magnitude of disparity (in absolute terms) among low-income individuals, thus suggesting they have greater potential health gains. Low-income individuals with strong SOC had comparable OHRQoL and HRQoL to high and middle-income respondents with weak SOC.

Participants with strong SOC and high income had the best OHRQoL and HRQoL in the fully adjusted model (model 4) (i.e. the lowest means of the OHIP-14 = 6.0 and the EQ-5D-3L = 0.6), resulting from the interaction between high income and strong SOC on OHRQoL and HRQoL. However, among low-income respondents, the absolute differences in both the OHIP-14 and the EQ-5D-3L means between strong and weak SOC were greater than among high-income respondents (3.9 vs 2.1 for OHRQoL, 0.9 vs 0.4 for HRQoL). That is, low-income individuals benefited from strong SOC more than those with high incomes regarding possible health gains (absolute differences between OHRQoL and HRQoL for those with strong and weak SOC were greater at the low-income level than at the high-income level). Strong SOC was associated with lower inequalities in relative terms in OHRQoL and HRQoL (i.e. income gradients had a shallower slope for those with strong SOC). Furthermore, strong SOC reduced the disparities (lower means of OHRQoL and HRQoL among low-income respondents with strong SOC -indicating better health than those with weak SOC). Among participants from low-income households, those with strong SOC had better OHRQoL and HRQoL than those with weak SOC, and comparable OHRQoL and HRQoL to higher income groups with weak SOC. These findings are congruent with previous studies, emphasising the importance of SOC as a beneficial psychological component affecting coping mechanisms in health adversities caused by low income (Makoge et al., 2019; Mizuta et al., 2020; Speirs et al., 2016). Since people from low-income levels have limited resources, strong SOC plays an important role in their coping ability with health challenges (Makoge et al., 2019). Strong SOC helps them reinterpret and cope with the stressors in a more manageable, comprehensible, and meaningful manner. Despite limited resources, low-income families with strong SOC tend to have healthier lifestyles, engage in healthier activities, and cope with stress more effectively (Speirs et al., 2016). A cross-sectional study on the association between healthy life choices and SOC in the United Kingdom showed a positive association between strong SOC and healthy behaviours independent of social class or level of education (Wainwright et al., 2007). Despite the importance of income and SES in shaping SOC, neither completely explains it. From a holistic perspective, SOC is more likely related to psycho-emotional factors (e.g. social relationships, family life, childhood living conditions, and employment quality), reflecting people's interpretations of their lives (Volanen et al., 2004). Bernabe et al. (2009) showed that childhood SES had a relatively small effect on adult's SOC. Their findings suggest that adults' SOC is influenced by factors other than childhood SES. Among low-income Japanese guardians (Mizuta et al., 2020), those with stronger SOC had children with lower caries prevalence.

A minimally important difference of 4-5 OHIP-14 units has been suggested (Locker et al., 2004), similar to the main effects observed for SOC and income in this study. As an impact score, the EQ-5D-3L values <1 have been equated to small to moderate effects in discriminating between different oral health conditions (Brennan, 2013). In our study, the EQ-5D-3L values of around one unit were observed for the main effects of SOC and income. Also, the effect size should be labelled according to the research field and the studied phenomenon (Durlak, 2009). Despite the small effect size found in this study, the findings are still meaningful on a practical level in social and behavioural studies (practical significance of the effect size). In other words, if the exposure is common, the small effect on the individual level could still have an extensive impact on the population. The cumulative effect of small psychological factors over time can be significant, especially if they affect behaviours and activities (Funder & Ozer, 2019). Also, in social and behavioural studies, the model fit statistics (R-Squared values) tend to be small; because it is impossible to include all possible predictors of an outcome in a model. Cohen suggested (1988) R-Squared values of 0.02, 0.13, and 0.26 for small, medium, and large model fit. Our models had R-Squared values ranging from 0.086 to 0.190, showing a good model fit.

Addressing income-related health adversities through broader SES interventions and policies to reduce poverty is important but challenging. However, strengthening individual dispositional factors (e.g. SOC) related to better health could effectively improve low-income people's health and quality of life. This empowerment approach could include salutogenic interventions that improve coping skills. The Salutogenesis framework is a promising approach emphasising the importance of "upstream" determinants and health-promoting strategies rather than being restricted to changing health behaviours (Antonovsky, 1979; Watt, 2007). By gaining a better insight into the stressors they face and the GRRs available in their lives, these approaches help people, vulnerable groups, and communities find the appropriate GRRs and empower them to manage the socioeconomic factors that influence their health (Super et al., 2016; Watt, 2007). Many holistic salutogenic interventions have also shown promising health outcome results (such as active adaptation approaches, cognitive behavioural therapy, and health education programs) (Suárez Álvarez et al., 2022). The implementation of these approaches can be achieved through large-scale health promotion programs similar to the

WHO healthy city project (easy and free access to psychological services and mental health promotion centres) for vulnerable groups.

The strengths of this study comprised: 1-using validated psychometric measures for oral and general health and SOC, 2-using a large South Australian representative sample, 3-analyses based on four multivariate models to assess the persistent effects and modifications among them, and 4- using two outcome variables to compare the models for any consistent patterns across oral and general health. The low response rate may be considered a limitation (44.8%). However, according to the average survey response rates for over 30 years, our study's response rate was in line with other large surveys (which consistently were below 50%) (Baruch & Holtom, 2008). On the other hand, DCOHS participants were selected randomly from the Electoral Roll, an extensive comprehensive sampling frame. Comparison of the final study sample (n=3,786) with general South Australian population data found similar composition with slight differences in the younger and older age groups (probably due to different categorisation), and place of birth. Recent comparisons against population data confirmed that DCOHS is generally representative of the South Australian population (Song et al., 2020a; Song et al., 2020b). Additionally, due to the possibility of response bias, DCOHS was also compared with the final sample and participants with missing responses. The characteristics of the final sample and those excluded due to missing responses were highly representative of DCOHS. The final sample (n=3,786) provided a large dataset (highly representative of the DCOHS (n=4,494)) despite a slight reduction in sample size because of missing answers to the items of SOC, income, and both outcome variables. Also, the normality of the data was checked and based on benchmark literature for large sample sizes, outcome variables' kurtosis, and skewness indicated adequate normality (Kim, 2013). However, the analysis was repeated (as suggested by previous research (Kim, 2013)) using the transformed outcome variables (log) to correct for skewness (if applicable), and the results were consistent with those of the original data.

Conclusion

Our findings suggested that strong SOC modified the association between low-income and OHRQoL and HRQoL in a representative sample of South Australian adults. Strong SOC was associated with better OHRQoL and HRQoL among low-income respondents. Also, this study highlighted the main effects and interactions between SOC and income on OHRQoL and HRQoL. This study presents promising findings on the possibility of reducing income-related health disparities, which will contribute to future health services planning and policy-making. Taken together, these findings suggest the importance of strengthening SOC at a population level, specifically for low-income people as the vulnerable groups, which could improve their OHRQoL and HRQoL. Further population-based studies are needed to evaluate whether SOC modifies the effect of other SES components (such as social support, education, and employment) on health outcomes.

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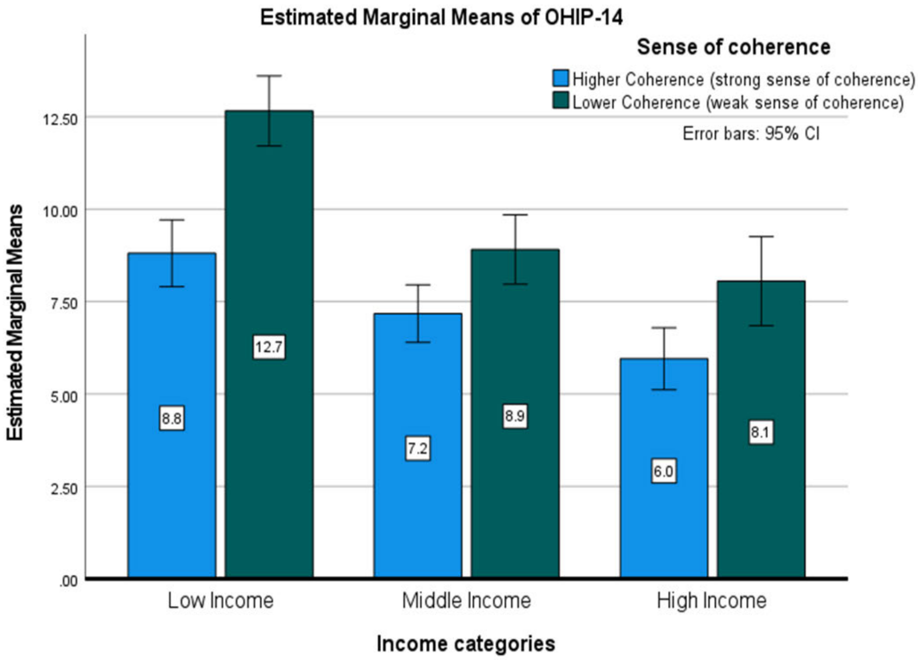

Fig. 1 Oral health-related quality of life by income groups and sense of coherence in Model 4 (fully adjusted model; adjusted the analyses for sex, age, the main language spoken at home, place of birth, daily tooth brushing, smoking, dental insurance and last dental visit.)

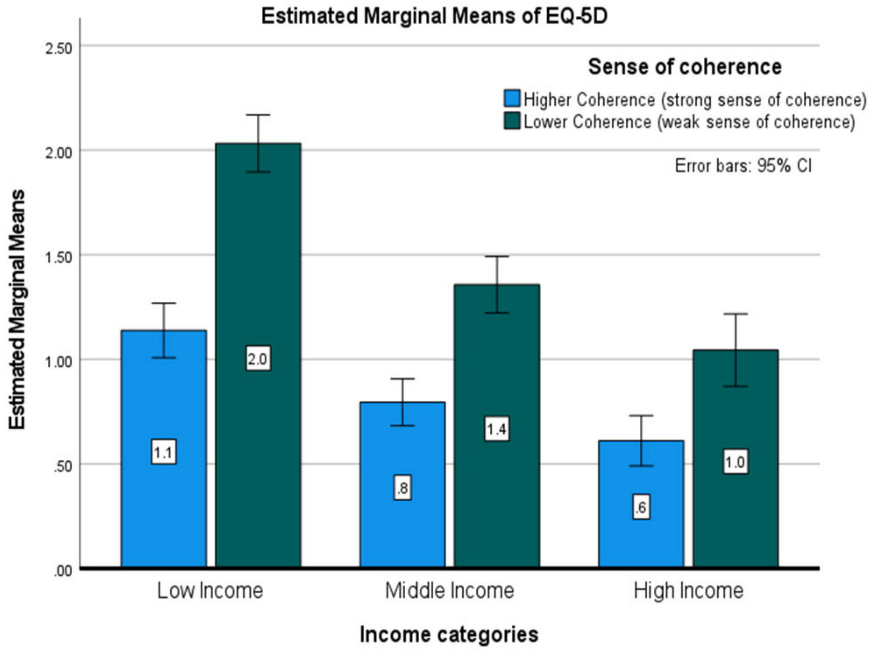

Fig. 2 Health-related quality of life by income groups and sense of coherence in Model 4 (fully adjusted model; adjusted the analyses for sex, age, the main language spoken at home, place of birth, daily tooth brushing, smoking, dental insurance and last dental visit.)

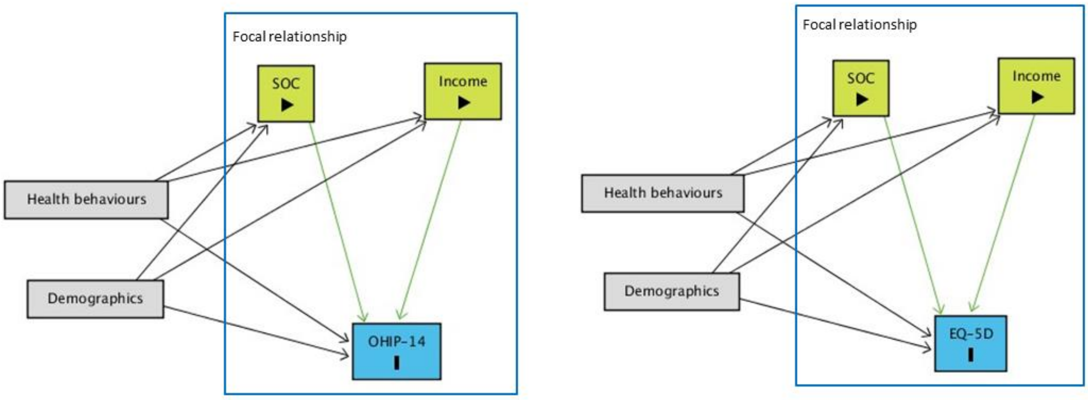

Fig. S1 Direct Acyclic Diagram (DAG) showing the focal relationships of sense of coherence (SOC) and income (the main exposures) with each outcome (OHIP-14 and EQ-5D)

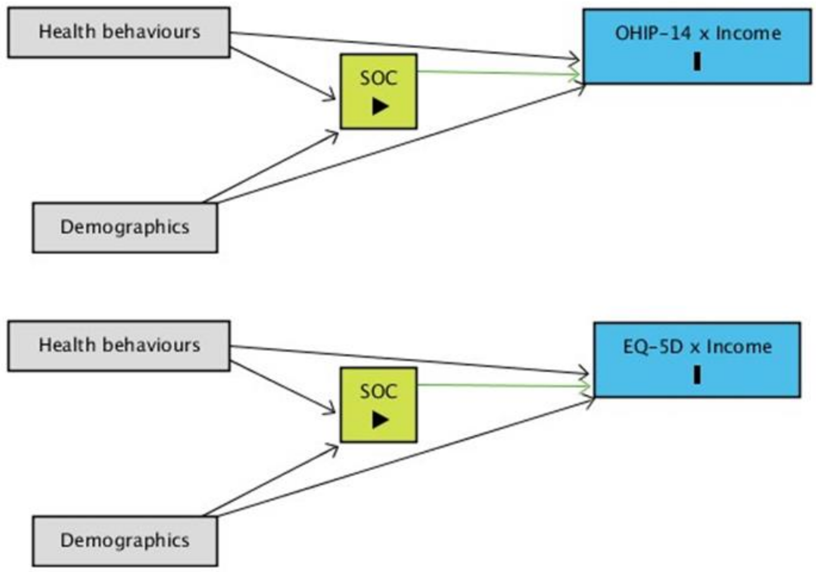

Fig. S2 Directed Acyclic Diagram (DAG) illustrating the interaction effect of sense of coherence (SOC) and income (the main exposures)

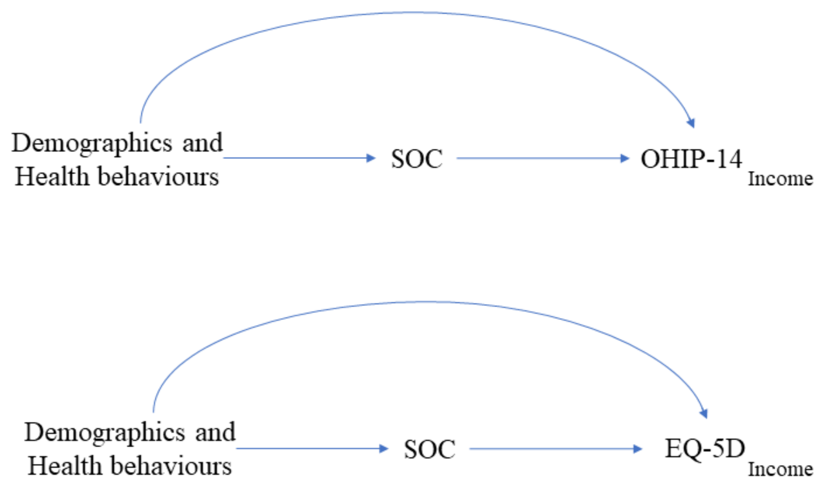

Fig. S3 Interaction Directed Acyclic Diagram (IDAG) of the interaction effect of sense of coherence (SOC) and income (the main exposures)

Table S1. Comparison of the study respondents' characteristics with DCOHS and excluded respondents from the analyses

	Final study sample (n=3786)*	DCOHS (n=4494)	Excluded respondents (n= 708)
	% (95% CI)	% (95% CI)	% (95% CI)
Health behaviour variables			
Last Dental Visit			
Less Than A Year Ago	61.2 (51.4-70.3)	61.1 (51.3-70.2)	60.3 (50.5-69.5)
A Year Ago And More	38.8 (29.7-48.6)	38.9 (29.8-48.7)	39.7 (30.5-49.5)
Dental Insurance			
Insured	68.7 (59.2-77.2)	66.1 (56.5-74.8)	59.0 (49.2-68.3)
Uninsured	31.3 (22.8-40.8)	32.2 (23.7-41.8)	41.0 (31.7-50.8)
Smoking Status			
Non-Smoker	54.5 (44.7-64.0)	54.3 (44.5-63.8)	53.6 (43.8-63.2)
Former Smoker	34.1 (25.4-43.7)	33.9 (25.2-435.5)	33.0 (24.4-42.6)
Current Smoker	11.5 (6.4-18.8)	11.8 (6.6-19.2)	13.5 (7.9-21.2)
Tooth Brushing			
Twice A Day Or More	54.6 (44.8-64.1)	53.8 (43.4 -62.8)	50.9 (41.2-60.6)
Less Than Twice A Day	45.4 (35.9-55.2)	46.2 (36.7-56.0)	49.1 (39.4-58.8)
Demographics			
Place of Birth			
Australia	78.9 (70.2-86.0)	78.7 (69.9-85.8)	77.8 (68.9-85.1)
Other	21.1 (14.0-29.8)	21.3 (14.2-30.1)	22.2 (14.9-31.1)
Main Language Spoken At			
English	95.6 (90.2-98.4)	95.5 (90.1-98.4)	94.9 (88.7-97.8)
Other	4.4 (1.6-9.8)	4.5 (1.6-9.9)	5.1 (2.0-10.7)
Sex			
Male	44.3 (34.8-54.1)	44.0 (34.6-53.8)	42.1 (32.8-51.9)
Female	55.7 (45.9-65.2)	56.0 (46.0-65.4)	57.9 (48.1-67.2)
Age Groups			
18-45 years	31.7 (23.2-41.2)	30.0 (21.7-39.5)	20.3 (13.3-29.0)
46-60 years	32.5 (23.9-42.1)	31.5 (23.0-41.0)	26.1 (18.3-35.3)
≥61 years	35.8 (26.9-45.5)	38.5 (29.4-48.3)	53.5 (43.7-63.1)

**based on the final analytic sample size comprising cases with non-missing data on all variables in the analysis*

Table S2. Comparison of the study respondents' characteristics with population data

	Final study sample [1]	Final study sample (weighted)[1]	2016 South Australia Census data
Demographics (%)			
Place of Birth			
Australia	78.9	81.6	71.1
Other	21.1	18.4	28.9
Sex			
Male	44.3	49.5	49.3
Female	55.7	50.5	50.7
Age Groups			
18-45 years	31.7	48.8	41.7*
46-60 years	32.5	25.7	26.5**
≥61 years	35.8	25.5	31.8***
Income Groups (%)			
≤$40,000	29.5	27.3	33.2[a]
$40,001 - $100,000	41.2	40.4	39.5[b]
≥ $100,001	29.3	32.3	27.2[c]

1: based on final analytic sample size comprising cases with non-missing data on all variables in the analysis

**20-44 years*
*** 45-59 years*
**** ≥60 years*

[a] ≤ $41,599 (<$799/week)
[b] $41,600 -$103,999 ($999-$1,999/week)
[c] ≥104,000 (≥$2,000/week)

Table 1. Characteristics of the study participants based on means of the OHIP-14 and the EQ-5D

	N (%)	OHIP- 14 Mean (SD)	EQ – 5D Mean (SD)
Total	**3786**	**6.3 (8.6)**	**0.9 (1.3)**
Health behaviour variables			
Last Dental Visit	3782		
Less Than A Year Ago	2315 (61.2)	5.8 (8.2)	0.8 (1.2)
A Year Ago And More	1467 (38.8)	6.9 (9.2)	1.0 (1.4)
Dental Insurance	3742		
Insured	2571 (68.7)	4.8 (6.8)	0.8 (1.1)
Uninsured	1171 (31.3)	9.2 (10.9)	1.2 (1.5)
Smoking Status	3763		
Non-Smoker	2049 (54.5)	5.0 (7.2)	0.7 (1.2)
Former Smoker	1282 (34.1)	6.8 (8.7)	1.1 (1.4)
Current Smoker	432 (11.5)	11.1 (12.3)	1.3 (1.5)
Tooth Brushing	3705		
Twice A Day Or More	2023 (54.6)	5.6 (8.2)	0.8 (1.2)
Less Than Twice A Day	1682 (45.4)	6.8 (8.9)	1.0 (1.4)
Demographics			
Place of Birth	3757		
Australia	2964 (78.9)	5.9 (8.3)	0.9 (1.2)
Other	793 (21.1)	7.7 (9.7)	1.1 (1.4)
Main Language Spoken At Home	3724		
English	3559 (95.6)	6.1 (8.6)	0.9 (1.3)
Other	165 (4.4)	8.0 (8.9)	1.0 (1.4)
Sex	3786		
Male	1678 (44.3)	6.0 (8.41)	0.8 (1.2)
Female	2108 (55.7)	6.6 (9.1)	1.0 (1.3)
Age Groups (Mean= 52.9)	3786		
18-45 years	1202 (31.7)	5.9 (8.1)	0.6 (1.1)
46-60 years	1229 (32.5)	6.8 (9.3)	1.0 (1.3)
≥61 years	1355 (35.8)	6.5 (9.0)	1.3 (1.5)
Sense of Coherence	3786		
Higher Coherence (Strong SOC*)	2703 (71.4)	5.1 (7.4)	0.7 (1.1)
Lower Coherence (Weak SOC)	1083 (28.6)	8.9 (10.4)	1.4 (1.6)
Income Groups	3786		
≤ $40 000	1117 (29.5)	9.5 (11.3)	1.6 (1.6)
$40 001 - $100 000	1559 (41.2)	5.9 (7.7)	0.8 (1.2)
> $100 000	1110 (29.3)	4.0 (6.1)	0.5 (0.8)

* Sense of Coherence

Table 2. Partial Eta squared from adjusted models of the OHIP-14

	Model 1[1]	Model 2[2]	Model 3[3]	Model 4[4]
SOC [a]	0.026**	0.024**	0.024**	0.019**
Income Groups	0.044**	0.046**	0.045**	0.023**
Income Groups * SOC	0.003**	0.003**	0.003**	0.003**
Model Adjusted R-squared	0.086	0.090	0.094	0.141
F value of interaction between Income Groups and SOC	6.312	5.396	5.732	4.892

** P<0.01
* P<0.05
NS: Not Significant
a: Sense of Coherence
1: Model 1, with only the interaction term between SOC and different income groups and the main effects of income and SOC.
2: Model 2 adjusted the analyses of model 1 for sex and age.
3: Model 3 adjusted the analyses of model 1 for sex, age, the main language spoken at home and place of birth.
4: Model 4 adjusted the analyses of model 1 for sex, age, the main language spoken at home, place of birth, daily tooth brushing, smoking, dental insurance and last dental visit.

Table 3. Partial Eta squared from adjusted models of the EQ-5D-3L

	Model 1[1]	Model 2[2]	Model 3[3]	Model 4[4]
SOC [a]	0.047**	0.059**	0.058**	0.054**
Income Groups	0.086**	0.055**	0.057**	0.043**
Income Groups * SOC	0.003**	0.005**	0.005**	0.005**
Model Adjusted R-squared	0.156	0.185	0.184	0.190
F value of interaction between Income Groups and SOC	5.540	10.166	9.697	9.319

** P<0.01

* P<0.05

NS: Not Significant

a: Sense of Coherence

1: Model 1, with only the interaction term between SOC and different income groups and the main effects of income and SOC.

2: Model 2 adjusted the analyses of model 1 for sex and age.

3: Model 3 adjusted the analyses of model 1 for sex, age, the main language spoken at home and place of birth.

4: Model 4 adjusted the analyses of model 1 for sex, age, the main language spoken at home, place of birth, daily tooth brushing, smoking, dental insurance and last dental visit.

5 Chapter 5: Personality traits and income inequalities in self-rated oral and general health

5.1 Highlights

- The main effects of conscientiousness on health-related quality of life (HRQoL) and emotional stability on oral health-related quality of life (OHRQoL) and HRQoL were found. Also, the interaction effects were observed between income and emotional stability with HRQoL and OHRQoL.

- High scores for positive personality traits (extraversion, conscientiousness, agreeableness, openness and emotional stability) were protective factors for OHRQoL and HRQoL at all income levels.

- Emotional stability modified the associations between income and OHRQoL and HRQoL. Low-income individuals with high emotional stability scores had similar OHRQoL to those from higher income levels but with low emotional stability scores. Those low-income individuals with high emotional stability scores had better HRQoL than those from middle-income with low emotional stability scores and similar to those from high-income levels with low emotional stability scores.

- High emotional stability scores were more beneficial psychological factors for low-income people than for high-income people in terms of their OHRQoL and HRQoL.

5.2 Statement of Authorship

Statement of Authorship

Title of Paper	Personality traits and income inequalities in self-rated oral and general health
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
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Principal Author

Name of Principal Author (Candidate)	Mehrsa Zakershahrak		
Contribution to the Paper	Conceptualisation, design and implementation of research methodology Data analysis, and model design Manuscript writing – original draft preparation Editing and revisions Performing duties as corresponding author		
Overall percentage (%)	80%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	22 August 2022

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate in include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	David Brennan		
Contribution to the Paper	Conceptualisation and supervision of design and development of research methodology Contributed to model design, data analysis and interpretation of the results Input in the manuscript's writing, editing and revisions		
Signature		Date	7 September 2022

Please cut and paste additional co-author panels here as required.

Study 2: Personality traits and income inequalities in self-rated oral and general health

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ORIGINAL ARTICLE

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Personality traits and income inequalities in self-rated oral and general health

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Abstract

The association of low income with poor health is widely recognized, but why some low-income individuals do not experience poor health remains unclear. The aim of this study was to determine whether greater positive personality trait scores modify the association between income and oral and general health-related quality of life (OHRQoL and HRQoL) among a representative sample of the South Australian population. Cross-sectional self-rated questionnaire data from a sample of 3645 adults in 2015–2016 were used for secondary analysis. In four factorial ANOVA models, the main effects, interaction, and effect modification of personality traits [measured using the Ten-Item Personality Inventory (TIPI)] on the association between income and OHRQoL [measured using the Oral Health Impact Profile (OHIP-14)] and HRQoL [measured using the European Quality of Life indicator (EQ-5D-3L)] were assessed. In the low-income group, participants with greater TIPI scale scores had lower means for the OHIP-14 and the EQ-5D-3L (better OHRQoL and HRQoL). Greater emotional stability scores modified the association between low income and HRQoL and OHRQoL. Stronger positive personality traits, such as emotional stability, appear to ameliorate the adverse effect of income inequalities in health.

KEYWORDS
health-related quality of life, patient outcome assessments, personality inventory, population health, socioeconomic status

INTRODUCTION

Despite the large body of literature that shows income gradients in health [1, 2], there is a lack of evidence to explain why some individuals remain healthy despite socioeconomic adversity. Psychosocial factors can be an important resource for low-income people to help them cope with stressors [3]. Positive psychosocial factors such as personality traits can help promote effective coping strategies that help low-income individuals successfully cope with the chronic stress they experience [4, 5].

The Wilson and Cleary model has been used to study the relationship between psychological factors and general and oral health [6, 7]. It explained how characteristics of the individual (e.g., personality) could influence functional health and health-related quality of life (HRQoL) [6, 7]. The link between people's health-related behaviors and personality can be explained using trait theories, such as the

'Big Five' [8]. The Big Five theory defines personality as a combination of five dimensions: extraversion, agreeableness, conscientiousness, openness to experience, and neuroticism [9].

Personality traits have moderating effects (described as modifying effects in the recent literature) [10] on HRQoL [11, 12]. Effect modification is where the effect of one exposure variable on the outcome variable differs at different levels of another exposure, while interaction is the joint effect of two exposures on the outcome variable [13]. People with high scores in extraversion (tendencies to socializing and interactivity), conscientiousness (being self-organized), agreeableness (inclination to be cooperative and affectionate with others), and openness (having greater mental adaptability and flexibility) have been shown to have better HRQoL and oral HRQoL (OHRQoL) [12, 14]. Those scoring high on neuroticism (low emotional stability, that is, having high stress and ineffective coping strategies) have been shown to have poorer HRQoL and OHRQoL [12, 14].

Notwithstanding the number of studies that have assessed the relationship between personality traits and subjective health (and income), this study aimed to fill two gaps in the literature: first, to estimate the interaction effect of the Big Five personality dimensions with income on self-rated health measures such as the Oral Health Impact Profile (OHIP-14) and the European Quality of Life indicator or EuroQol (specifically, the three-level response version, EQ-5D-3L); and second, to determine whether greater positive personality trait scores modify the association between low income and OHRQoL and HRQoL, using a representative population sample in South Australia. The research questions were 'What is the association between income and personality traits (main effects) and their interaction with OHRQoL and HRQoL' and 'Do greater positive personality traits modify the association between low income and general and oral health?'

MATERIAL AND METHODS

Data collection

Data from the Dental Care and Oral Health Study (DCOHS) were used. A total of 12,245 South Australian adults aged 18 years or over were randomly selected from the Electoral Roll. Self-rated questionnaires were mailed to them to participate voluntarily and confidentially in the study (2015–2016) with three follow-up mail reminders. The secondary analysis for this cross-sectional study used the responses from the baseline survey (n = 4494, response rate = 44.8%), which were weighted by population estimates to represent the age and sex distribution of the population of South Australia. The collected data included sociodemographic characteristics, self-rated general and oral health, health-related behaviors, and psychosocial factors. Ethics approval was derived from the Human Research Ethics Committee of the University of Adelaide (H-288-2011) [15, 16].

Outcome variables

The EQ-5D-3L and the OHIP-14 were selected as outcome variables representing HRQoL and OHRQoL, respectively. In the Wilson and Cleary model, the EQ-5D-3L and OHIP-14 conceptually can be considered as functional health [17, 18]. The EQ-5D-3L measures health problems using five items (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) with three response levels [19]. The EQ-5D-3L was recently psychometrically validated in the general population in Australia and showed acceptable reliability [20]. Responses to the EQ-5D-3L were coded as 0 (no problem/none), 1 (some problems), and 2 (extreme problems) [21] to match the other outcome variable (OHIP-14) as the impact score. Thus, individuals with no problems were anchored at a score of zero. The HRQoL was computed by summing scores across the five items (ranges from 0 to 10), with higher scores representing poorer HRQoL. The OHIP-14 uses 14 items that represent self-reported oral health in seven dimensions (functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap). The OHIP-14 has been validated in Australia, showing good validity and high reliability [22]. Responses were coded with a Likert-type scale from 0 (never) to 4 (very often). The possible score ranges from 0 to 56, and respondents with higher scores have poorer OHRQoL.

Explanatory variable

The explanatory variable was total household income collected in Australian Dollars in 10 categories ranging from <\$20,000 to more than \$180,000. Income was categorized into three groups (to achieve an approximate even distribution): 0–\$40,000, \$40,001–\$100,000, and >\$100,000.

Effect modifier

The effect modifiers were the Ten-Item Personality Inventory (TIPI) dimensions to evaluate the psychosocial factors. The TIPI has been validated in many countries, showing acceptable psychometric validity and test-retest reliability [23–25]. The TIPI was designed as a brief self-rated instrument to measure the Big Five personality dimensions with two items for each trait (a standard item and a reverse-scored item in each trait). These personality dimensions comprise extraversion (being social, enthusiastic), agreeableness (trustworthiness, being empathetic), conscientiousness (self-discipline, reliability, self-efficacy), emotional stability (the opposite dimension to neuroticism; being balanced, calm, capability of remaining stable), and openness (curiosity and creativity, being open-minded). Each item was rated on a seven-point Likert-type scale ranging from 1 (Disagree Strongly) to 7 (Agree Strongly). Responses to reverse-scored items were recoded (the recoded reverse-scored items) to be consistent with standard items. Then, the average of the standard item and the recoded reverse-scored item were calculated to make up each dimension's scale score which ranged from 1 to 7 (higher scale scores reflecting a higher level of each trait) [23]. Based on the responses, we were able to determine where respondents fell on each trait spectrum. Each TIPI scale score was categorized by the conceptual approach, which was dividing the scale according to whether the scores were equal to being 'agree' or higher (on average) to create two categories: lower TIPI (<5 as disagree) and higher TIPI categories (5–7 as agree). Any dimension scale score that produced agree and higher scores indicated a higher level of that trait and were considered as a higher TIPI category.

Covariates

Other variables included in the models were sociodemographic characteristics (age, sex, place of birth, and the main language spoken at home) and health-related behaviors (smoking status, dental insurance, last dental visit, and tooth brushing). To achieve a roughly even distribution of ages, we divided the population into three age groups (18–45, 46–60, and 61 years and older). Place of birth was coded into two groups (Australian-born or born in other countries). Dental insurance was grouped into insured and uninsured individuals. Language spoken at home was dichotomized as English speakers and non-English speakers. Smoking status was coded into three categories (current smokers, former smokers, and never smoked). Tooth brushing frequency was dichotomized as twice a day, and more or less than twice a day. Similarly, the last dental visit was used to classify respondents into two groups: those who had dental visits <12 months ago or visited the dentist 1 year ago or more.

Data analysis

The study's analysis was limited to the complete cases sample (respondents with full answers to all TIPI dimensions, income, the EQ-5D and the OHIP-14 items; $n = 3645$). Four factorial ANOVA models (general linear models) were conducted to examine the association between TIPI dimensions and income level (main effects) and their interaction with each outcome (the OHIP-14 and then the EQ-5D-3L). First, the simple crude model (model 1) was applied to evaluate the interaction and main effect between TIPI dimensions and income levels. We then used a structured approach to add potential confounders in consecutive blocks. In other words, we added the conceptually relevant covariates (sociodemographic factors and health-related behaviors) in subsequent steps. Thus, model 2 controlled for sex and age. Model 3 adjusted for all of the sociodemographic covariates. Model 4 adjusted for all covariates (sociodemographic factors and health-related behaviors). These four models assessed whether the associations between income and HRQoL (EQ-5D-3L) and OHRQoL (OHIP-14) were modified by different levels of each dimension of the TIPI (Figures S1–S3 in the Supporting Information).

This study focused on the effect sizes of income and personality traits, which are presented using partial ETA-squared (η_p^2). Standardized effect sizes for factorial ANOVA are usually measured by η_p^2. According to the benchmark literature, $\eta_p^2 < 0.0099$ is considered as no effect, a value of η_p^2 between 0.0099 and < 0.0588 is considered a small effect size, and a value of η_p^2 between 0.0588 and < 0.1379 is considered an intermediate effect size [26].

Moreover, to check the factorial ANOVA's assumptions (which apply to residuals instead of the original data values), the skewness and kurtosis values were calculated for the outcome variables (dependent variables). Kurtosis for the OHIP-14 was 5.19, and for the EQ-5D, it was 2.94. Skewness for the OHIP-14 was 2.15, and for the EQ-5D, it was 1.69. These values were interpreted with established benchmarks in the literature as representing sufficient normality. Based on Kim's article [27], for large sample size data 'Either an absolute skew value larger than 2 or an absolute kurtosis (proper) larger than 7 may be used as reference values for determining substantial non-normality'. However, we repeated the analysis using transformed outcome variables (log OHIP-14 and log EQ-5D-3L) to correct for skewness (if any). The results were consistent with the untransformed outcome in terms of effect size, interaction, effect modification, and significance. This justified using the untransformed outcome variables for the main analysis. All analyses were repeated for each scale. SPSS version 28 (IBM) was used for the statistical analysis.

RESULTS

Table 1 demonstrates the characteristics of the sample participants. The majority of respondents were female (55.5%), had dental insurance (68.9%), and never smoked (54.3%). The OHIP-14 and EQ-5D-3L mean scores were the lowest (indicating better OHRQoL and HRQoL) among those non-smokers and dentally insured respondents.

TABLE 1 Descriptive characteristics of the study respondents

	N (%)	OHIP-14 Mean (SD)	EQ-5D Mean (SD)
Total sample	**3645**	**6.2 (8.6)**	**0.9 (1.3)**
Last dental visit ($n = 3640$)			
Less than a year ago	2245 (61.7 %)	5.8 (8.1)	0.8 (1.2)
A year ago and more	1395 (38.3 %)	6.8 (9.1)	1.0 (1.4)
Dental insurance ($n = 3605$)			
Insured	2484 (68.9 %)	4.9 (6.9)	0.8 (1.2)
Uninsured	1121 (31.1 %)	9.0 (10.7)	1.1 (1.5)
Cigarette smoking ($n = 3626$)			
Non-smoker	1969 (54.3 %)	5.0 (7.2)	0.7 (1.2)
Former smoker	1237 (34.1%)	6.7 (8.6)	1.1 (1.4)
Current smoker	420 (11.6%)	10.8 (12.2)	1.2 (1.5)
Tooth brushing ($n = 3570$)			
Twice a day or more	1956 (54.8 %)	5.5 (8.0)	0.8 (1.2)
Less than twice a day	1614 (45.2 %)	6.9 (8.8)	1.0 (1.3)
Place of birth ($n = 3621$)			
Australia	2866 (79.1 %)	6.0 (8.3)	0.9 (1.2)
Other	755 (20.9 %)	7.4 (9.3)	1.1 (1.4)
Main language spoken at home ($n = 3589$)			
English	3436 (95.7 %)	6.1 (8.5)	0.9 (1.3)
Other	153 (4.3 %)	7.7 (8.5)	1.0 (1.4)
Sex ($n = 3645$)			
Male	1622 (44.5 %)	6.0 (8.1)	0.8 (1.2)
Female	2023 (55.5 %)	6.5 (9.0)	1.0 (1.3)
Age groups (years) ($n = 3645$) (Mean = 52.6) (Range = 18–86)			
18–45	1179 (32.3 %)	5.9 (8.0(	0.6 (1.0)
46–60	1193 (32.8 %)	6.7 (9.3)	0.9 (1.3)
61 and older	1273 (34.9 %)	6.4 (8.8)	1.3 (1.5)

Participants mostly were in the middle-income level (41.2%) and had high TIPI scale scores except for extraversion, where 64.3% had low scores (Table 2). The lowest means of the OHIP-14 and the EQ-5D-3L (better OHRQoL and HRQoL) belonged to the high-income threshold and those with high emotional stability scores.

We fitted a range of generally consistent models, and for reasons of parsimony, only one set is presented in detail, along with the essential findings from the other models. Table 3 presents the association between the TIPI dimensions and household income and their interaction with OHRQoL (OHIP-14) in model 4. There was no evidence for statistical significance of the interaction terms, but small effects for emotional stability ($F(1,3424) = 57.5$) and income in model 4 were observed. Other personality traits had no association (no effect) with the OHIP-14 in model 4.

In other models, the association between income and the OHIP-14 (models 2 and 3, as presented in Table S3 and S5, respectively) showed an intermediate effect (for openness and agreeableness), while conscientiousness (model 1, as presented in Table S1) and emotional stability (models 1–3, as presented in Table S1, S3, and S5, respectively) still had small effects. There was also a statistically significant association between the interaction effect of income and emotional stability and OHRQoL (OHIP-14) in the other models except for model 4 [model 1 (Table S1), $F(2, 3639) = 7.37$, $p < 0.01$, $\eta^2_p = 0.004$, Adjusted $R^2 = 0.081$; model 2 (Table S3), $F(2, 3636) = 6.68$, $p < 0.05$, $\eta^2_p = 0.004$, Adjusted $R^2 = 0.086$; and model 3 (Table S5), $F(2, 3556) = 6.38$, $p < 0.05$, $\eta^2_p = 0.004$, Adjusted $R^2 = 0.088$].

Table 4 shows the association between income and the five dimensions of the TIPI (main effects) and their interaction effects with the EQ-5D-3L. The interaction effect between income and emotional stability with HRQoL (EQ-5D-3L) in model 4 was statistically significant ($F(2, 3424) = 11.47$, $p < 0.001$, $\eta^2_p = 0.007$, Adjusted $R^2 = 0.214$). The effect size of

TABLE 2 Descriptive characteristics of the study respondents by explanatory variable and effect modifiers

	N (%)	OHIP-14 Mean (SD)	EQ-5D Mean (SD)
Total sample	**3645**	**6.2 (8.6)**	**0.9 (1.3)**
TIPI			
Extraversion ($N = 3645$)			
Higher	1302 (35.7%)	5.4 (8.0)	0.7 (1.2)
Lower	2343 (64.3%)	6.6 (8.8)	1.0 (1.3)
Openness ($N = 3645$)			
Higher	2108 (57.8%)	5.8 (8.3)	0.8 (1.2)
Lower	1537 (42.2%)	6.8 (8.8)	1.0 (1.4)
Agreeableness ($N = 3645$)			
Higher	2351 (64.5%)	6.0 (8.4)	0.8 (1.3)
Lower	1294 (35.5%)	6.5 (8.7)	1.0 (1.3)
Conscientiousness ($N = 3645$)			
Higher	2936 (80.5%)	5.7 (8.1)	0.8 (1.2)
Lower	709 (19.5%)	8.1 (9.9)	1.2 (1.5)
Emotional Stability ($N = 3645$)			
Higher	2059 (56.5%)	4.9 (7.4)	0.5 (1.0)
Lower	1586 (43.5%)	7.9 (9.6)	1.3 (1.4)
Income Groups ($n = 3645$)			
≤$40 000	1055 (28.9 %)	9.3 (11.1)	1.6 (1.6)
$40 001–$100 000	1501 (41.2 %)	5.9 (7.7)	0.8 (1.2)
>$100 000	1089 (29.9 %)	4.0 (6.1)	0.5 (0.8)

Abbreviation: TIPI, Ten-Item Personality Inventory.

TABLE 3 Partial eta-squared values of oral health-related quality of life in Model 4 (while controlled for all covariates[a])

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional stability
Last dental visit	0.001[NS]	0.001[NS]	0.001[NS]	0.001*	0.001*
Dental insurance	0.019**	0.019**	0.019**	0.018**	0.018**
Cigarette smoking	0.028**	0.028**	0.027**	0.025**	0.024**
Tooth brushing	0.005**	0.004**	0.004**	0.004**	0.004**
Place of birth	0.002**	0.003**	0.002**	0.003**	0.002**
Main language spoken at home	0.000[NS]	0.000[NS]	0.000[NS]	0.000[NS]	0.000[NS]
Sex	0.004**	0.004**	0.005**	0.004**	0.003**
Age groups	0.005**	0.005**	0.004**	0.004**	0.004**
TIPI	0.001*	0.002**	0.002*	0.006**	0.017**
Income groups	0.024**	0.028**	0.028**	0.022**	0.023**
Income groups * TIPI	0.000[NS]	0.001[NS]	0.000[NS]	0.001[NS]	0.002[NS]
Model adjusted R^2	0.116	0.117	0.116	0.120	0.129

Abbreviations: NS, not significant; TIPI, Ten-Item Personality Inventory.

[a]Model 4 controlled for all characteristics (age, sex, place of birth, and the main language spoken at home) and health-related behaviors (smoking status, dental insurance, last dental visit, and tooth brushing).

*$p < 0.05$.

**$p < 0.01$.

TABLE 4 Partial eta-squared values of healt-related quality of life in Model 4 (while controlled for all covariates[a])

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional stability
Last dental visit	0.001[NS]	0.001[NS]	0.001*	0.001[NS]	0.000[NS]
Dental insurance	0.001[NS]	0.001[NS]	0.001[NS]	0.001[NS]	0.001[NS]
Cigarette smoking	0.011**	0.011**	0.010**	0.009**	0.008**
Tooth brushing	0.003**	0.003**	0.003**	0.002**	0.003**
Place of birth	0.000[NS]	0.000[NS]	0.000[NS]	0.000[NS]	0.000[NS]
Main language spoken at home	0.000[NS]	0.000[NS]	0.000[NS]	0.000[NS]	0.000[NS]
Sex	0.007**	0.006**	0.008**	0.006**	0.003**
Age groups	0.016**	0.015**	0.019**	0.019**	0.025**
TIPI	0.004**	0.005**	0.009**	0.012**	0.081**
Income groups	0.049**	0.056**	0.056**	0.041**	0.046**
Income groups * TIPI	0.001[NS]	0.001[NS]	0.000[NS]	0.000[NS]	0.007**
Model adjusted R^2	0.145	0.143	0.146	0.150	0.214

Abbreviations: NS, not significant; TIPI, Ten-Item Personality Inventory.

[a]Model 4 controlled for all characteristics (age, sex, place of birth, and the main language spoken at home) and health-related behaviors (smoking status, dental insurance, last dental visit, and tooth brushing).

*$p < 0.05$.

**$p < 0.01$.

conscientiousness and income on EQ-5D-3L was small, while emotional stability had an intermediate effect size. Other TIPI dimensions had no effects.

Similarly, in models 1–3 (as presented in Tables S2, S4, and S6, respectively), the association between HRQoL (EQ-5D-3L) and income (for all traits except for conscientiousness in models 2 and 3), and emotional stability and HRQoL showed intermediate effects. The association between conscientiousness and HRQoL (models 1–3) showed a small effect (Tables S2, S4, and S6), while agreeableness had a small effect in model 2 (Table S4). Other TIPI dimensions had no effect (Tables S2, S4, and S6). Moreover, there was a statistically significant association between the interaction effect of emotional stability and income with EQ-5D-3L in other models [model 1 (Table S2), $F(2, 3639) = 8.74$, $p < 0.001$, $\eta_p^2 = 0.005$, Adjusted $R^2 = 0.182$; model 2 (Table S4), $F(2, 3636) = 11.16$, $p < 0.001$, $\eta_p^2 = 0.006$, Adjusted $R^2 = 0.210$; and model 3 (Table S6), $F(2, 3556) = 11.75$, $p < 0.001$, $\eta_p^2 = 0.007$, Adjusted $R^2 = 0.209$].

For the model fit statistics, the adjusted R-squared values for oral health outcome (OHIP-14), from model 1 (no covariates, as presented in Table S2) to model 4 (adjusted for all covariates, as presented in Table 4) were 59% to 100% higher. For health outcome (EQ-5D-3L), the adjusted R-squared values increased from 18% to 29% from model 1 (no covariates, as presented in Table S2) to model 4 (fully adjusted model, as presented in Table 4). These higher adjusted R-squared values indicated that the additional input variables were adding additional explanatory value to the models.

The effect modification of emotional stability was observed in the association between different income categories and

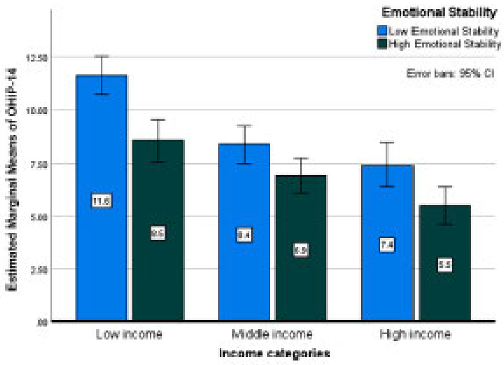

FIGURE 1 Oral health-related quality of life [measured using the Oral Health Impact Profile (OHIP-14)—marginal means and 95% CI] by emotional stability and income levels in Model 4 (while controlled for all covariates; sociodemographic characteristics and health-related behaviors)

OHRQoL in model 4. While there was no statistically significant association between the interaction effect of income and emotional stability and OHRQoL, respondents in the low-income category and with high emotional stability had comparable OHIP-14 (mean = 8.5, 95% CI = [7.6, 9.5]) to others with low emotional stability but in the middle (mean = 8.4, 95% CI = [7.5, 9.2]) and high-income categories (mean = 7.4, 95% CI = [6.4, 8.4]), as shown in Figure 1. Also, the effect modification of emotional stability in the association between income and HRQoL in model 4 was observed,

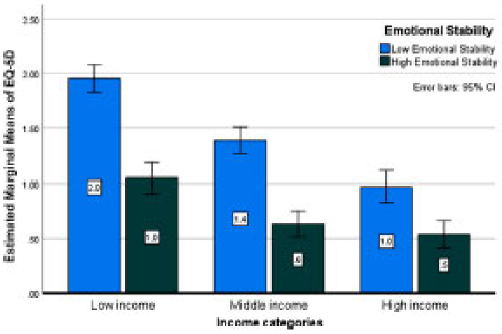

FIGURE 2 Health-related quality of life [measured using the European Quality of Life indicator (EQ-5D)—marginal means and 95% CI] by emotional stability and income levels in Model 4 (while controlled for all covariates; sociodemographic characteristics and health-related behaviors)

where there was evidence for the association between the interaction of income and TIPI dimension with the EQ-5D-3L. The EQ-5D-3L of those at the low-income level and with high emotional stability (mean = 1.0, 95% CI = [0.9, 1.2]) were comparable to participants of high-income status but with low emotional stability (mean = 1.0, 95% CI = [0.8, 1.1]), as shown in Figure 2.

DISCUSSION

This study evaluated the association between income and personality traits (main effects) and their interaction effects with OHRQoL and HRQoL, along with the effect modification of greater positive personality traits in the association between low income and general and oral health. High income and high personality traits such as emotional stability and conscientiousness were associated with better self-reported health measures. The interaction between emotional stability and income was associated with better HRQoL (in all models) and OHRQoL (in models not adjusted for health behaviors). Low-income individuals with greater TIPI scale scores had better OHRQoL and HRQoL than participants with weak TIPI scores. Findings for effect modification suggested that high emotional stability (as a positive personality trait) had a modifying effect in the association between income and OHRQoL and HRQoL.

One of the main interests of this study was the modifying role of personality traits in the association between income and HRQoL and OHRQoL (the effect measure modification analysis). While it is both necessary and desirable to try to improve the social determinants of health, this study assessed whether greater positive personality traits could help to protect low-income people against poor oral and general health. The examination of effect modification allowed us to identify differences in the associations between income (as the exposure) and OHRQoL and HRQoL (as the outcome variables) based on each level of the personality trait dimensions (greater or lower) as the effect modifier [13]. Categorizing personality traits (as the epidemiological exposure measures in a population-based study) in terms of higher and lower scores allowed us to identify the association between the adverse effect of low income and HRQoL and OHRQoL when lower scores on personality traits were contrasted with high. Rothman [28] suggested that one can code exposure variables into categories, while there could be some disadvantages (e.g., the possibility of losing some information, statistical power, and the need for more terms in the model). When the sample size is large, these potential drawbacks are usually insignificant [28]. However, categorization allows for the estimation of effects for each level of exposure without being limited by any specific pattern ('the advantage of the unconstrained estimation of separate effects outweighs the disadvantages in most situations') [28]. Also, by dichotomizing the exposure, it is possible 'to avoid misspecification of the outcome model in interaction analyses' of continuous exposure [29]. According to Richters [30], the use of dichotomous data focuses on individuals' differences instead of variables. Therefore, we can determine what proportion of individuals possess a particular explanatory factor (variable) or combination of explanatory factors, as well as what specific explanatory factors affect the individual (e.g., What is the proportion of people with higher scores on personality traits among low-income individuals? What are the effects of higher scores of personality traits on low-income people's health?). For psychological traits, such as personality, it is important to consider types of individuals rather than assuming homogeneity and where each individual falls on the continuum for each trait (i.e., towards which end of the spectrum).

The greater absolute differences in OHRQoL and HRQoL between respondents with low and high emotional stability in the low-income group (3.1 for the OHIP-14 and 1.0 for the EQ-5D-3L means) than in the high-income group (1.9 for the OHIP-14 and 0.5 for the EQ-5D-3L means) suggested a greater potential health gain from high emotional stability for the low-income group than the high-income group. The findings for effect modification are congruent with past studies that evaluated the moderation effect of personality traits such as emotional stability on the impact of socioeconomic and clinical factors on subjective HRQoL [31–33]. In this study, respondents with greater TIPI scale scores (higher positive personality traits) rated the EQ-5D-3L and the OHIP-14 with the lowest scores (better HRQoL and OHRQoL) across all models unrelated to their income categories. These findings are supported by studies that reported personality characteristics as greater determinants of health and HRQoL than age [34] and socioeconomic variables like income [35]. Similar to our findings on the main effects of personality traits, low conscientiousness and emotional stability scores have been associated with poor self-rated health [36]. Furthermore, a study on older Japanese reported that participants with low emotional stability scores had poorer OHRQoL, regardless of financial status, number of teeth, and occlusal force [37].

Income-related health inequalities are complex, and addressing them through socioeconomic interventions and anti-poverty programs is difficult. However, it could be possible to improve positive psychosocial factors among low-income groups to help them manage their health problems. This could be achieved through interventions that target psychosocial factors (for example, personality interventions that focus on those traits related to risky health behaviors [38]). Also, holistic approaches such as applying interventions at the community level by using positive psychology for low-income groups [39], mental health promotion programs [40], and providing psychosocial supports and establishing supportive environments for mental health [41, 42] could be beneficial for vulnerable groups. Psychological interventions (using behavioral changes) have shown positive effects in improving oral health behaviors [43].

Although some of the effect sizes found in this study are small, they are still meaningful on the practical level in the related research area. The best approach, especially in social and behavioral epidemiological studies, is to consider practical significance along with statistical significance and effect size. Labelling the effect size depends entirely on the research field and the phenomenon being studied. It should also be noted that small effects can still be important (e.g., when the prevalence of exposure is common, a small effect may impact the population widely, even if relatively small at the individual level). When determining the importance of exposure, the nature of the outcome that is being predicted is more important than the magnitude of the exposure's effect on the outcome [44]. These seemingly small effects could be important in predicting critical life outcomes (such as health) because of their cumulative and practical effects over time [45, 46]. The effects of psychological factors (such as personality traits) that impact behavior and interpersonal relationships can accumulate over time and have an impact on health and quality of life [46]. A perfect example of this is the surprisingly small association between using aspirin and reducing heart attacks. A study of the patients of 10,845 medical doctors found that aspirin prevented only 85 heart attacks [47]. Despite the small effect size of aspirin in that study, the practical significance of the association should not be missed. In terms of cumulative effects, a relatively small effect that has a negative impact on pursuing education at a young age could lead to a significant impact on health and well-being in the future [48].

According to Cohen's suggestion [49], model fit statistics include R-squared values of 0.02, 0.13, and 0.26, which are considered small, medium, and large, in that order. These values in epidemiological studies are usually low, and they do not mean that a model does not fit. We can never expect models (especially in the social or behavioral sciences) to include all relevant predictors that could explain an outcome variable [50, 51].

Income and emotional stability had a significant interaction when adjusted for sociodemographic characteristics. After adjusting for all covariates, the interaction between income and emotional stability was not observed, indicating the effect of adding health behaviors (as covariates). That the improved overall model fit when successive blocks of covariates were added showed that adjusting the models for health behaviors explained new variations in OHRQoL (i.e., health behaviors are associated with the residuals of the crude model), while they decreased the estimated effect of income and personality traits and their interaction effect. Therefore, personality traits cannot fully explain OHRQoL (personality traits have an overlap in variance explained with health behaviors). In other words, health behaviors can explain (to some extent) the association between personality traits and OHRQoL.

The study's strengths comprise a large state-wide representative sample size, using standard and validated self-rated health and personality trait measures, and applying the analysis through four models with different adjusted variables. Limitations include a low response rate (at 44.8%). Despite survey response rates in the last 30 years being usually below 50% [52], response bias (survey dropouts may have different answers from respondents) [53] could be possible. However, the latest evaluations of population data confirmed that the DCOHS (derived from the Electoral Roll as a comprehensive sample frame) broadly represents the age and sex distribution of South Australia's population [15, 16]. Also, the relatively small reduction in sample size caused by missing responses had no major impact on our statistical power due to the large representative sample size we had available to analyze [54, 55].

In conclusion, we assessed the effect of personality trait scores on the self-reported oral and general health measures in a representative sample of the South Australian population. The findings suggested that the associations between income and HRQoL and OHRQoL were modified by emotional stability. Our study found an interaction effect between income and emotional stability with HRQoL and OHRQoL. However, the absence of a statistically significant interaction effect after adjusting for health behaviors suggests that the association between personality traits and OHRQoL can be explained to some extent through health behaviors. This study can help policymakers and researchers design effective interventions that improve personality traits, health, and quality of life.

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CONFLICTS OF INTEREST

The authors declare there are no possible conflicts of interest.

AUTHOR CONTRIBUTIONS

Conceptualization : Mehrsa Zakershahrak, David Brennan; **Methodology**: Mehrsa Zakershahrak, David Brennan; **Formal analysis**: Mehrsa Zakershahrak; **Investigation**: Mehrsa Zakershahrak; **Writing—original draft preparation**: Mehrsa Zakershahrak; **Writing—review and editing**: Mehrsa Zakershahrak, David Brennan; **Supervision**: David Brennan.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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Table S1. Partial Eta Squared Values of OHRQOL In Model 1†

	Extraversion	**Openness**	**Agreeableness**	**Conscientiousness**	**Emotional stability**
TIPI	0.001*	0.002**	0.002*	0.010**	0.025**
Income groups	0.047**	0.056**	0.056**	0.043**	0.047**
Income groups * TIPI	0.000NS	0.001NS	0.000NS	0.001NS	0.004**
Model Adjusted R-Squared	0.058	0.058	0.058	0.066	0.081

** P<0.01

* P<0.05

NS: Not Significant

TIPI: The Ten-Item Personality Inventory

†: Model 1 or crude model included the main effects of income and personality traits (measured using TIPI), as well as interactions between personality traits (measured using TIPI) with different income groups.

Table S2. Partial Eta squared values of HRQoL in Model 1†

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
TIPI	0.004**	0.006**	0.005**	0.011**	0.077**
Income Groups	0.092**	0.108**	0.105**	0.078**	0.096**
Income Groups * TIPI	0.001NS	0.001NS	0.000NS	0.000NS	0.005**
Model Adjusted R-squared	0.114	0.115	0.113	0.120	0.182

** P<0.01

* P<0.05

NS: Not Significant

TIPI: The Ten-Item Personality Inventory

†: Model 1 or crude model included the main effects of income and personality traits (measured using TIPI), as well as interactions between personality traits (measured using TIPI) with different income groups.

Table S3. Partial Eta squared values of OHRQoL in Model 2†

	Extraversion	**Openness**	**Agreeableness**	**Conscientiousness**	**Emotional Stability**
Sex	0.000^{NS}	0.000^{NS}	0.001^{NS}	0.001^{NS}	0.000^{NS}
Age Groups	0.008**	0.008**	0.007**	0.007**	0.006**
TIPI	0.001*	0.002**	0.002*	0.009**	0.023**
Income Groups	0.052**	0.062**	0.061**	0.046**	0.050**
Income Groups * TIPI	0.000^{NS}	0.001^{NS}	0.000^{NS}	0.000^{NS}	0.004**
Model Adjusted R-squared	0.065	0.065	0.065	0.072	0.086

** P<0.01

* P<0.05

NS: Not Significant

TIPI: The Ten-Item Personality Inventory

†: Model 2 controlled for sociodemographic characteristics (sex and age).

Table S4. Partial Eta Squared Values of HRQoL in Model 2†

	Extraversion	**Openness**	**Agreeableness**	**Conscientiousness**	**Emotional Stability**
Sex	0.003^{**}	0.002^{**}	0.004^{**}	0.003^{**}	0.001^{NS}
Age Groups	0.022^{**}	0.020^{**}	0.025^{**}	0.026^{**}	0.033^{**}
TIPI	0.005^{**}	0.005^{**}	0.010^{**}	0.017^{**}	0.087^{**}
Income Groups	0.066^{**}	0.079^{**}	0.077^{**}	0.056^{**}	0.062^{**}
Income Groups * TIPI	0.001^{NS}	0.001^{NS}	0.000^{NS}	0.000^{NS}	0.006^{**}
Model Adjusted R-Squared	0.135	0.134	0.137	0.144	0.210

** P<0.01

* P<0.05

NS: Not Significant

TIPI: The Ten-Item Personality Inventory

†: Model 2 controlled for sociodemographic characteristics (sex and age).

Table S5. Partial Eta Squared Values of OHRQoL In Model 3†

	Extraversion	**Openness**	**Agreeableness**	**Conscientiousness**	**Emotional Stability**
Place of Birth	0.002**	0.002**	0.002**	0.003**	0.002**
Main Language Spoken at Home	0.000 NS	0.000NS	0.000NS	0.000NS	0.000NS
Sex	0.000NS	0.000NS	0.001NS	0.001NS	0.000NS
Age Groups	0.008**	0.009**	0.008**	0.007**	0.006**
TIPI	0.001 NS	0.002**	0.002**	0.009**	0.023**
Income Groups	0.053**	0.061**	0.060**	0.045**	0.049**
Income Groups * TIPI	0.000NS	0.001NS	0.000NS	0.000NS	0.004**
Model Adjusted R-Squared	0.067	0.068	0.067	0.074	0.088

** P<0.01
* P<0.05
Ns: Not Significant
Tipi: The Ten-Item Personality Inventory

†: Model 3 controlled for all sociodemographic characteristics (age, sex, place of birth and the main language spoken at home).

Table S6. Partial Eta squared values of HRQoL in Model 3†

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
Place of Birth	0.000^{NS}	0.000^{NS}	0.000^{NS}	0.000^{NS}	0.000^{NS}
Main Language Spoken At Home	0.000^{NS}	0.000^{NS}	0.000^{NS}	0.000^{NS}	0.000^{NS}
Sex	0.003**	0.002**	0.004**	0.003**	0.001^{NS}
Age Groups	0.019**	0.018**	0.022**	0.023**	0.030**
TIPI	0.004**	0.005**	0.009**	0.016**	0.086**
Income Groups	0.068**	0.079**	0.078**	0.056**	0.063**
Income Groups * TIPI	0.002^{NS}	0.001^{NS}	0.000^{NS}	0.000^{NS}	0.007**
Model Adjusted R-squared	0.134	0.133	0.137	0.143	0.209

** P<0.01

* P<0.05

NS: Not Significant

TIPI: The Ten-Item Personality Inventory

†: Model 3 controlled for all sociodemographic characteristics (age, sex, place of birth and the main language spoken at home).

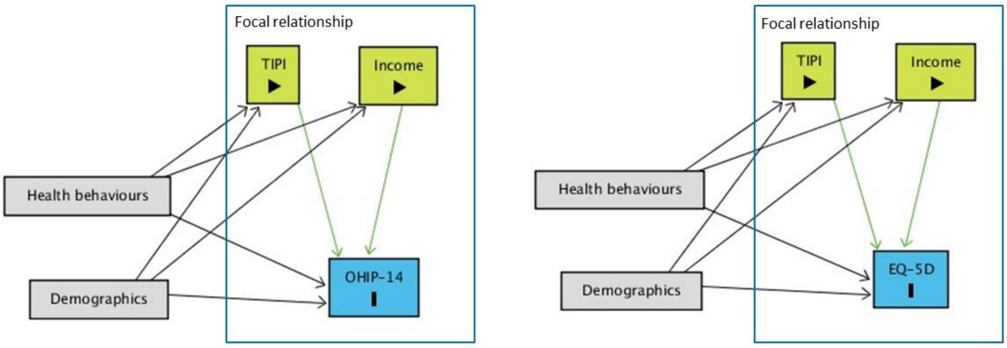

Figure S1. The Directed Acyclic Diagram (DAG) of the focal relationships between the main exposures (income and personality traits - measured using Ten-Item Personality Inventory (TIPI)) and each outcome individually (measured using the European Quality of Life indicator (EQ-5D) and the Oral Health Impact Profile (OHIP-14))

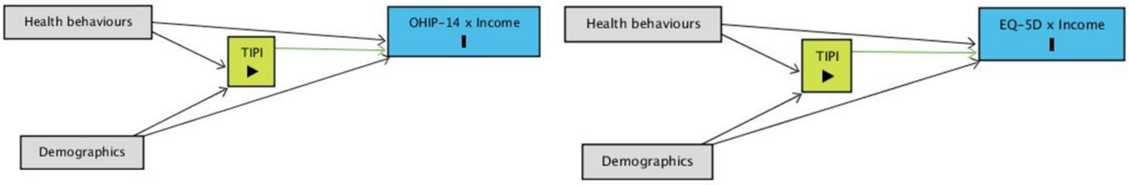

Figure S2. The Directed Acyclic Diagram (DAG) of the interaction effect of the main exposures (income and personality traits - measured using Ten-Item Personality Inventory (TIPI)) for each outcome individually (measured using the European Quality of Life indicator (EQ-5D) and the Oral Health Impact Profile (OHIP-14))

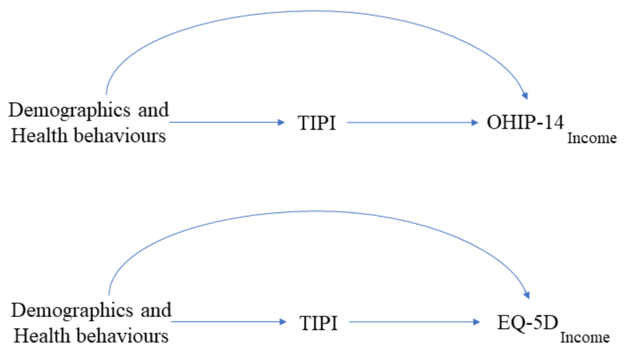

Figure S3. The Interaction Directed Acyclic Diagram (IDAG) of the interaction effect of the main exposures (income and personality traits - measured using Ten-Item Personality Inventory (TIPI)) for each outcome individually (measured using the European Quality of Life indicator (EQ-5D) and the Oral Health Impact Profile (OHIP-14))

6 Chapter 6: Sense of coherence, modifier of the association between income and self-rated oral and general health, a cross-sectional study

6.1 Highlights

- The protective effect of the strong sense of coherence (SOC; i.e., high coherence in terms of the relative strength of the concept of SOC) for self-rated dental and general health (SRDH and SRGH, respectively) were observed at all income levels.

- The modifying effect of strong SOC was observed in the association between low-income and poor SRDH and SRGH.

- Low-income respondents with strong SOC had comparable SRGH to those from middle-income with weak SOC (low coherence in terms of the relative strength of the concept of SOC).

- Strong SOC was found to be more beneficial for low-income respondents than high-income respondents for their SRDH and SRGH.

6.2 Statement of Authorship

Statement of Authorship

Title of Paper	Sense of coherence, modifier of the association between income and self-rated oral and general health, a cross-sectional study
Publication Status	☐ Published ☐ Accepted for Publication ☑ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
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Principal Author

Name of Principal Author (Candidate)	Mehrsa Zakershahrak		
Contribution to the Paper	Conceptualisation, design and implementation of research methodology Data analysis, and model design Manuscript writing – original draft preparation Editing and revisions Performing duties as corresponding author		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	22 August 2022

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate in include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Contribution to the Paper	Conceptualisation and supervision of design and development of research methodology Contributed to model design, data analysis and interpretation of the results Input in the manuscript's writing, editing and revisions		
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Study 3: Sense of coherence, modifier of the association between income and self-rated oral and general health, a cross-sectional study

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Abstract

Objectives: The aim was to investigate whether a stronger Sense of Coherence (SOC) modifies the association between low household income and poor self-rated dental and general health measures (SRDH and SRGH, respectively). **Methods:** Cross-sectional analyses were performed using data from the Dental Care and Oral Health Study (DCOHS, 2015-2016) in South Australia (n=3,664). In multivariate Poisson regression models, the main effects, interactions, and effect modification of SOC in the association between income and SRDH and SRGH were estimated using prevalence ratios (PRs) for poor self-rated health. **Results:** Lower coherence (weak SOC) was associated with poor SRGH (PR=4.8, 95% C.I [1.8-13.1]). The interaction between lower coherence and low and middle-income strata was not associated with the prevalence of poor SRDH and SRGH. In the low-income group, among those with stronger SOC, the prevalence of both poor SRDH (16.0%) and SRGH (8.1%) was lower than those with weaker SOC (25.0% and 18.9%). **Conclusions:** Findings suggested that strong SOC modified the association between low income and poor health ratings. This study suggests the possibility of reducing income-health disparities by applying SOC-based interventions to future healthcare policies.

Keywords: low income, Sense of Coherence, oral health, salutogenic, self-rated health

Introduction

The relationship between socioeconomic status (such as income) and health has been extensively studied, and research has suggested that low-income status and poor health are causally related (Benzeval & Judge, 2001; Bernabé et al., 2015; Sabbah et al., 2007). Although socioeconomic adversity related to income exacerbates many factors that contribute to poor health, some individuals can still maintain good health and control their health problems, even when faced with adverse circumstances such as low income and poverty (Bonanno, 2005; Chen et al., 2011; Mizuta et al., 2020). Observations of positive outcomes in adverse circumstances have contributed to a paradigm shift in health from a pathogenic model to a model focusing on health and well-being. Sociologist Aaron Antonovsky developed the concept of Salutogenesis to explain how some people are able to cope with extreme stress, stay healthy and have greater resilience to illness than their counterparts under similar hardship conditions (Antonovsky, 1979, 1987, 1995). The Salutogenic theory is based on the Sense of Coherence (SOC) and general resistant resources (GRR) and focuses on factors that enhance well-being and health rather than causes of disease (Antonovsky, 1979, 1987, 1993).

SOC reflects the individual's outlook on life and the capacity to respond to stressful and difficult challenges using a health-promoting approach (Antonovsky, 1979, 1987, 1993; Silva et al., 2008; Volanen, 2011). SOC comprises three components: comprehensibility (the ability to comprehend life situations clearly), manageability (the ability to cope effectively with stressful life events and have the resources to cope with stressors), and meaningfulness (motivation to cope with challenges, knowing that challenges deserve engagement and coping) (Antonovsky, 1987, 1993). SOC is a predictor of coping ability as an individual characteristic (Eriksson & Lindström, 2011; Makoge et al., 2019) and improves how people manage stress in their lives effectively (Volanen et al., 2004). SOC is shaped by the GRRs influenced by economic factors, social support, culture, and effective coping strategies (Antonovsky, 1979, 1987; Horsburgh & Ferguson, 2012; Idan et al., 2017). Individuals use GRRs to manage stress (Idan et al., 2017). The GRRs improve health by enabling people to adopt healthy lifestyles and eliminate unhealthy habits (Savolainen et al., 2009). SOC appears to have a moderating effect (also recently known as modifying effect (Knol & VanderWeele, 2012)) on health under stressful conditions (Feldt, 2002). Also, an interaction between the parent/guardian's SOC and socioeconomic status on the oral health status of low-income children has been reported (Mizuta et al., 2020). Effect modification occurs if the effect of one exposure on the outcome variable varies in another exposure's strata (VanderWeele, 2009). Interaction is defined as two exposure variables' combined and joint effects on the outcome (VanderWeele, 2009).

Those who face socioeconomic adversities related to income cannot rely solely on economic factors (as GRRs) to maintain resilience and cope with health challenges. They need other psychological GRRs, such as SOC (which is influenced by genetics, environment, education achievement, beliefs, healthy behaviours, mindsets, rituals and religion (Antonovsky, 1979, 1987; Horsburgh & Ferguson, 2012; Idan et al., 2017)). Despite facing socioeconomic adversities related to income, some people seem to "beat the odds" (Luthar, 2003) and have a positive outlook on life. They still have a strong SOC and do well regarding their oral and general health. According to Makoge et al. (2019), there was no association between strong SOC and income in poverty groups coping with diseases. They concluded that income and social factors are not related to the coping ability of people living in poverty (mainly determined by low income) while coping was strongly associated with the individual's dispositional factors, such as SOC (Makoge et al., 2019). SOC is shown to be positively related to oral health behaviours (Bernabé et al.,

2009) and healthier lifestyles (Wainwright et al., 2007), independent of socioeconomic status and demographic factors.

In low-income groups, factors other than income could affect the ability to cope with disease (Makoge et al., 2019). For this reason, a multidimensional approach is needed to identify the coping-related factors among low-income individuals. Despite the relationship between SOC and coping with illness, there is not enough evidence on whether SOC can modify the income-health association (Eriksson & Lindström, 2006; Lundberg & Peck, 1994; Poppius et al., 1999). Thus, our study aimed to estimate: first, the association of SOC and income and their interaction effect with poor self-rated oral health/general health; and second, whether strong SOC can modify the association between low-income level and poor self-rated oral health/general health among a representative adult population in South Australia.

Methods

Baseline data from the Dental Care and Oral Health Study (DCOHS) were used for this study's sample and analysis. In all, 12,245 South Australian adults aged 18 years and older were randomly selected from the Electoral Roll and received invitations to participate in DCOHS by mail. Questionnaires were sent with up to three follow-up reminders. Participation was voluntary and confidential. Finally, 4,494 people completed and returned the questionnaire, yielding a 44.8% response rate after excluding undeliverable mail. The responses were weighted using South Australian population estimates from the Australian Bureau of Statistics to reflect the sex and age distribution of the state. The Human Research Ethics Committee of the University of Adelaide approved the study (H-288-2011) (Song et al., 2020a; Song et al., 2020b).

The single-item global ratings measuring self-rated dental and general health (SRDH and SRGH, respectively) were the outcome variables. These ratings were measured on 5-point Likert scales by asking the questions: "How would you rate your dental health?" and "How would you rate your general health?". Based on the Wilson and Cleary model (1995), SRDH and SRGH are conceptually assessed as general health perceptions (Baker et al., 2008) and are related to individual characteristics (e.g. psychosocial factors). According to previous studies (Cislaghi & Cislaghi, 2019; Teusner et al., 2014), SRDH and SRGH were dichotomised into respondents with either good, very good or excellent ratings and others with poor to very poor ratings. Responses rated good to excellent in both SRDH and SRGH were considered as the reference category.

Income was the main explanatory variable. The household's total gross income (before tax) in Australian Dollars was divided into three approximately equal categories (approximate tertiles) (≤$40k, >$40k-100k, and >$100k).

The three-item SOC scale (one question per component) was used to assess the association of SOC with the income-health gradient (Lundberg & Peck, 1995). The 3-item SOC is a valid and time-saving instrument for large population research surveys (Chiesi et al., 2018). Responses to meaningfulness and manageability dimensions were coded as Yes, usually=0, Yes, sometimes=1, and No=2. Responses to Comprehensibility were reverse-coded to align with the other dimensions. SOC total scores ranged from 0 to 6, with lower scores reflecting higher coherence (stronger SOC). According to previous studies (Lundberg & Peck, 1994), SOC total scores were categorised as strong (0 to 2) and weak (3 to 6).

Only complete responses (respondents who answered all items completely) of SOC, income, and both health ratings were analysed (n=3,936). Also, Poisson regression excluded missing covariate cases (n=272). Thus, n=3,664 was the final sample size. The final sample was compared to census data to explore representativeness, and also the missing cases were compared to the non-missing cases (final sample respondents) to assess potential bias.

The models also comprised sociodemographic variables (age, sex, the language mainly spoken at home and country of birth) and health behaviour variables (dental insurance coverage, smoking status, daily toothbrushing and last dental visit). The age groups were categorised as 18-45, 46-60 and >60 years. Country of birth was classified as born in Australia and born overseas. The language mainly spoken at home was dichotomised as English and languages other than English. Dental insurance coverage was coded as insured and uninsured individuals. Smoking status was grouped as current, former and non-smokers. Daily tooth brushing was categorised as individuals who brushed their teeth at least twice daily and others who brushed less than twice daily. Lastly, dental visits were classified as those who made a dental visit within the past year and those who visited one year ago or more.

This study evaluated the unadjusted associations between income and SOC with poor SRDH and later with poor SRGH (model 1 or crude model). The crude model included the interaction between income and SOC with each health outcome separately and the main effects of income and SOC. Then, adjusted associations between health outcomes, income and SOC were assessed in multivariable models (models 2 to 4) by including conceptually relevant covariates (sociodemographic characteristics and health behaviours) in consecutive blocks. Model 2 was controlled for sex and age. Model 3 was controlled for all sociodemographic variables (sex, age, language and country of birth); Model 4 was adjusted for all sociodemographic factors and health behaviour variables (daily toothbrushing, smoking, dental insurance and last dental visit). These models assessed whether the relationship between poor SRDH and SRGH (separately) and income was modified by SOC, along with the interaction term between SOC and income with poor SRDH and SRGH separately (Figures S1-S3). Prevalence ratios of poor to very poor SRDH and SRGH adjusted for covariates were estimated using Poisson regression. According to Pearson Chi-Square (Value/df >0.05), all models for each health rating fit the data. Using Poisson regression with robust error variance (a correction for over-dispersion) yielded Exponential Beta to estimate prevalence ratios (PRs), a more precise way of assessing effect size in cross-sectional studies (Barros & Hirakata, 2003). The analyses were conducted using IBM's SPSS software version 28.

Results

The final analysis contained n=3,664 responses (after excluding participants with missing responses, n=830). Given the possibility of response bias, participants in the final study sample were compared to those with missing responses on a range of characteristics (Table S1). Overall, both groups had similar distributions for sex, the main language spoken at home, country of birth, smoking status and last dental visit. The excluded participants (due to missing responses) were more likely to be uninsured and older, although these differences were not statistically significant.

The final study sample was compared to the South Australian census data to determine its representativeness (Table S2). The final sample (weighted) was similar to the population of South Australia. There were minor differences in country of birth (mostly Australian born), age groups (a higher percentage of younger age group), and income categories (a higher percentage of high-income category), which were partly because age groups and income categories were classified differently in the current study compared to census data.

Participants in the final study sample (n=3664) were more likely to be female (55.8%), non-smokers (54.5%), from the middle-income group (41.5%), dental insured (68.9%) and reporting strong SOC (72.1%) (Table 1). Findings showed that 11.4% of the sample had poor SRDH and 5.5% had poor SRGH. The prevalence of poor SRDH and SRGH was lower among 18-45 years old, non-smokers, dentally insured, those who brushed their teeth twice daily or more, high-income group and those with stronger SOC.

Across all models, low- and middle-income categories were significantly associated with poor SRDH, with PRs ranging from 1.8 to 3.3 (Table 2). In other words, there was a higher prevalence of poor SRDH among low- and middle-income respondents than among high-income respondents. There was no statistically significant association between poor SRDH and weak SOC in any of the models. The interaction between lower coherence (weak SOC) and low- and middle-income were not associated with the prevalence of poor health ratings in all models.

Poor general health had higher PRs among low (all models) and middle-income groups (model 2) than the high-income group (Table 3). For poor SRGH, low-income had a larger effect (PRs ranging from 5.3 to 9.3) than middle-income, with PR=2.2 for model 2. According to all models, poor general health was more prevalent in respondents with weak SOC with PRs ranging from 4.8 to 5.5, showing a large effect of weak SOC for the prevalence of poor self-rated general health. The interaction effect between low- and middle-income and weak SOC were not associated with poor SRGH across all models.

Among low-income participants, those with strong SOC had a lower prevalence of poor SRDH and SRGH than those with weak SOC (Figures 1 and 2). In the low-income group, the prevalence of poor dental health was lower in those with strong SOC (16.0%) than weak SOC (25.0%). Also, among low-income individuals, those with strong SOC (8.1%) had a lower prevalence of poor SRGH than those with weak SOC (18.9%). Interestingly, the prevalence of poor SRGH among those low-income respondents with strong SOC (8.1%) was comparable to those from the middle-income category but with weak SOC (7.6%).

Discussion

In this study, we assessed the effect modification of strong SOC in the association between income and poor SRDH and SRGH, along with the association of the interaction and main effects of SOC and income with poor SRDH and SRGH. Findings suggested that weak SOC was associated with poor SRGH (all models). Also, poor SRDH and SRGH were associated with low income across all models. Middle income was associated with poor SRDH (all models) and poor SRGH (model 1). The interaction effects of income and SOC were not associated with poor self-rated oral and general health. However, our findings suggest that there was a modifying effect of strong SOC in the association between income and poor SRDH and SRGH, with more significant disparities in absolute terms among low-income respondents, pointing to groups where larger potential health gains could be achieved.

Our findings showed that the prevalence of poor SRDH (4.2%) and SRGH (1.0%) was lowest for those with strong SOC and high income, possibly due to the association between the combined effect of strong SOC and high income with health. However, the absolute differences in the prevalence of poor SRDH and SRGH between strong and weak SOC were greater at low income (9.0% for SRDH, 10.8% for SRGH) than at high income

(4.0% for SRDH, 3.6% for SRGH). In other words, the income gradient was steeper for those with strong SOC than for those with weak SOC, which partially was because of the lower prevalence of poor health ratings for those with strong SOC at the high-income level. However, strong SOC was more advantageous in terms of potential health gains for low-income individuals than those with high incomes in absolute terms (larger absolute differences in the prevalence of poor health ratings among low-income participants between strong and weak SOC). As a result, having strong SOC increased inequality in relative terms (income gradient was steeper for those with strong SOC) but reduced disparity (lower prevalence of poor health ratings among those low-income participants with strong SOC). As low-income individuals have limited resources, a strong SOC (as the individual dispositional factor) can significantly affect their coping abilities with health challenges (Makoge et al., 2019) (reframing stressors as more manageable, comprehensible, and meaningful) and could benefit them more than the high-income group. Low-income families with strong SOC are more likely to adopt healthy behaviours and health-promoting activities and handle stressful situations better (even with limited resources) (Speirs et al., 2016). It should be noted that the association between strong SOC and health-promoting behaviours was reported regardless of social class and education (Wainwright et al., 2007).

In line with previous research, this study highlights the significance of SOC as a valuable psychological resource for coping strategies in the adverse effects of low socioeconomic status related to income on health (Makoge et al., 2019; Mizuta et al., 2020; Speirs et al., 2016). Children of low-income parents/guardians with strong SOC had a lower prevalence of caries (Mizuta et al., 2020). SOC appears to be a protective psychological factor for children against dental caries when faced with socioeconomic adversity (Tomazoni et al., 2019). Also, SOC could effectively promote dental health, specifically for those living below the poverty line (Mizuta et al., 2020). For those facing socioeconomic adversities related to income, economic factors alone, as GRRs, will not suffice to maintain resilience and cope with health challenges. Despite the fact that SOC is influenced by income and socioeconomic status, neither can explain it entirely. According to Bernabe et al. (2009), childhood socioeconomic level has a relatively small impact on SOC in adulthood. Their study suggested that other factors besides childhood socioeconomic status can affect SOC in adulthood. The differences between people's SOC (as an individual dispositional factor) are more complex than based solely on a person's socioeconomic status (Antonovsky, 1979, 1987; Horsburgh & Ferguson, 2012). When viewed from a holistic perspective, SOC has a strong relationship with the psycho-emotional components and can be regarded as a reflection of a person's interpretations of life (e.g., social and interpersonal connections, childhood environments and experiences, employment status) (Volanen et al., 2004). Besides, those with strong SOC have significantly better social competence (the behavioural, emotional and learning skills for successful social adjustment and interaction) than others with weak SOC (Mattila et al., 2011). Consequently, they might be better able to cope with low-income situation stressors and thrive in these circumstances.

According to our findings, weak SOC was associated with poor SRGH. It was also evident that strong SOC was associated with good health. These findings align with cross-sectional studies that have suggested the association between strong SOC and good health, i.e. fewer illness symptoms and subjective complaints (Eriksson & Lindström, 2006). Strong SOC was shown to be a predictor of good health in adults (Suominen et al., 2001). There is evidence that strong SOC can reduce the incidence of health problems such as circulatory disorders and heart disease (Lundberg & Peck, 1994; Poppius et al., 1999). Also, SOC and self-rated health were found to be positively associated (Von

Bothmer & Fridlund, 2003). Strong SOC was positively associated with a variety of health behaviours among adolescents, such as non-smoking, less drinking, and better oral hygiene (Länsimies et al., 2017). The association between strong SOC and health can be explained to some extent through these healthy behaviours (Länsimies et al., 2017).

Low-income individuals could have different abilities and opportunities to cope with challenges in health (Makoge et al., 2019). Their coping capacities are influenced by other factors besides income, such as individual dispositional factors (e.g. SOC) that affect their perception of and reliance on the relevant resources and their drive to use those available resources (Makoge et al., 2019). However, because of the lack of privilege and power in their lives, they may face many obstacles and intersecting oppressions. Thus, focusing on the psychological resources that low-income people can use to cope with stressors rather than relying on broader social policies (which can be difficult to change) could be an effective and practical way to reduce income-health disparities. For this reason, salutogenic interventions to enhance the coping skills and capacities among low-income people (as the vulnerable groups) could benefit these groups in managing their health challenges successfully. Salutogenesis, as a promising framework, focuses on the "upstream" determinants and health-promoting mechanisms and is not limited to changing health behaviours (Antonovsky, 1979; Watt, 2007). These upstream-targeted approaches emphasise empowering individuals and communities to select suitable GRRs and to enable more control of the socioeconomic factors affecting their health by having a better perception of the stressors and GRRs they deal with (Super et al., 2016; Watt, 2007). Additionally, other holistic salutogenic interventions include active adaptation strategies, cognitive behavioural therapy, and health education programs that have shown positive health outcomes (Suárez Álvarez et al., 2022).

This study features several strengths: 1-using a large and state-representative sample, 2-using multivariable regression models to find persistent associations among the models, 3- measuring health and SOC with validated and reliable self-reported instruments, and 4- using oral and general health measures to assess the similar patterns between them. Limitations include a moderate response rate of 44.8% for the DCOHS, but this aligns with the response rates (<50%) experienced by other human research surveys in the past three decades (Baruch & Holtom, 2008). Despite the moderate response rate, it should be noted that the DCOHS responses were drawn randomly from the Electoral Roll (a large and comprehensive survey frame), and recent comparisons of population data have shown the representativeness of the DCOHS to the age and gender distributions of South Australian adults (Song et al., 2020a; Song et al., 2020b). However, the current study's participants were compared to the general population census data (2016) of South Australia. The current study's final sample was broadly representative of the South Australian adult population, with slightly different distributions of age groups and income (possibly related to classification differences) and country of birth. Moreover, a comparison between DCOHS, the current study's final sample and the excluded participants showed that the possibility of response bias (i.e. the responses of dropouts could differ from those of respondents) was minimal.

Conclusions

Findings showed the association between weak SOC and poor self-rated dental and general health. Furthermore, the associations between the effects of SOC and income with the prevalence of both health ratings were indicated. The associations between strong SOC and lower prevalence of poor SRDH and SRGH in low-income groups suggested that income-related health disparities can be modified by strong SOC. The findings indicated that the association between the effect of income with self-rated oral and general health was different depending on stronger or weaker SOC. This study provides promising and significant evidence on salutogenic health promotion approaches in income-related health disparities, which sets the stage for future research and policy decisions. Future research is needed on the other determinants of socioeconomic status (such as employment, education, and housing).

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Table 1. Poor self-rated dental and general health by characteristics of study respondents

	Distributions * (n=3664)	SRDH Poor to very poor		SRGH Poor to very poor	
	N (%)	N (%)	95% CI	N (%)	95% CI
(n=3664)		**416 (11.4%)**	**10.3-12.5**	**203 (5.5%)**	**4.8-6.4**
Health behaviour variables					
Last Dental Visit					
Within The Past Year	2267 (61.9%)	187 (8.2%)	7.1-9.5	101 (4.5%)	3.6-5.4
One Year Ago And More	1397 (38.1%)	229 (16.4%)	14.3-18.4	102 (7.3%)	6.0-8.9
Dental Insurance					
With Insurance	2524 (68.9 %)	198 (7.8%)	6.7-8.9	98 (3.9%)	3.2-4.7
Without Insurance	1140 (31.1%)	218 (19.1%)	16.7-21.8	105 (9.2%)	7.5-11.1
Smoking Status					
Non-Smoker	1998 (54.5%)	150 (7.5%)	6.4-8.8	78 (3.9%)	3.1-4.9
Former Smoker	1225 (34.3%)	151 (12.0%)	10.2-14.1	90 (7.2%)	5.8-8.9
Current Smoker	411 (11.2%)	115 (28.0%)	23.1-33.6	35 (8.5%)	5.9-11.8
Toothbrushing Frequency					
Twice Daily Or More	2010 (54.9%)	143 (7.1%)	6.0-8.4	77 (3.8%)	3.0-4.8
Less Than Twice Daily	1654 (45.1%)	273(16.5%)	14.6-18.6	126 (7.6%)	6.3-9.1
Sociodemographic characteristics					
Country Of Birth					
Australia	2890 (78.9%)	305 (10.6%)	9.4-11.9	136 (4.7%)	3.9-5.6
Other Countries	774 (21.1%)	111 (14.3%)	11.8-17.3	67 (8.7%)	6.7-11.0
Main Language Spoken At Home					
English Speakers	3505 (95.7%)	390 (11.1%)	1.0-12.3	184 (5.2%)	4.5-6.0
Other Languages	159 (4.3%)	26 (16.4%)	10.7-24.0	19 (11.9%)	7.2-18.7
Sex					
Male	1620 (44.2%)	223 (13.8%)	12.0-15.7	113 (7.0%)	5.7-8.4
Female	2044 (55.8%)	193 (9.4%)	8.1-10.9	90 (4.4%)	3.5-5.4
Age Categories (Mean= 52.9)					
18-45 years	1166 (31.8%)	96 (8.2%)	6.7-10.1	33 (2.8%)	1.9-4.0
46-60 years	1184 (32.3%)	147 (12.4%)	10.5-14.6	63 (5.3%)	4.1-6.8
61-86 years	1314 (35.9%)	173 (13.2%)	11.3-15.3	107 (8.1%)	6.7-9.8
Sense of Coherence					
Higher Coherence (Strong Sense *of Coherence)*	2641 (72.1%)	244 (9.2%)	7.4-9.7	85 (3.2%)	2.6-4.0
Lower Coherence (Weak Sense *of Coherence)*	1023 (27.9%)	172 (16.8%)	14.4-19.5	118 (11.5%)	9.5-13.8
Income Categories					
High (> $100 000)	1077 (29.4%)	53 (4.9%)	3.7-6.4	18 (1.7%)	1.0-2.6
Middle ($40 001 - $100 000)	1521 (41.5%)	156 (10.3%)	8.7-12.0	55 (3.6%)	2.7-4.7
Low (≤$40 000)	1066 (29.1%)	207 (19.4%)	16.9-22.3	130 (12.2%)	10.2-14.5

*** Based on the final analytic sample size comprising cases with non-missing data on all variables in the analysis**

Table 2. Prevalence ratios from all models of poor self-rated dental health

	Model 1[a]	Model 2[b]	Model 3[c]	Model 4[d]
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
Sense Of Coherence *(Ref. Category: Higher Coherence (Strong SOC))*	1.8[NS] (0.9-3.6)	1.9[NS] (1.0-3.6)	1.9[NS] (1.0-3.6)	1.4[NS] (0.8-2.7)
Low-Income Category *(Ref. Category: High Income Category)*	3.2** (2.1-4.8)	3.3** (2.2-5.1)	3.3** (2.2-5.0)	2.1** (1.4-3.2)
Middle-Income Category *(Ref. Category: High Income Category)*	2.2** (1.5-3.4)	2.3** (1.5-3.5)	2.3** (1.5-3.5)	1.8** (1.2-2.7)
Interaction of Low-Income Category and Lower Coherence (Weak SOC)	1.0[NS] (0.5-2.0)	1.0[NS] (0.5-2.0)	1.0[NS] (0.5-2.0)	1.0[NS] (0.5-2.0)
Interaction of Middle-Income Category and Lower Coherence (Weak SOC)	0.7[NS] (0.3-1.4)	0.6[NS] (0.3-1.4)	0.6[NS] (0.3-1.4)	0.7[NS] (0.4-1.5)

** P<0.01
* P<0.05
NS: Not Significant

Ref. Category*:* Reference Category
PR: Prevalence Ratios
SOC: Sense of coherence

a: Model 1 comprised the interactions of SOC with different income groups and the main effects of income and SOC.
b: Model 2 adjusted for sociodemographic variables: sex and age.
c: Model 3 adjusted for all sociodemographic variables: sex, age, the main language spoken at home, and country of birth.
d: Model 4 adjusted for all sociodemographics (sex, age, the main language spoken at home and country of birth) and all health behaviour variables (daily toothbrushing, smoking, dental insurance and last dental visit).

Table 3. Prevalence ratios from all models of poor self-rated general health

	Model 1[a]	Model 2[s]	Model 3[c]	Model 4[d]
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
Sense Of Coherence *(Ref. Category: Higher Coherence (Strong SOC))*	5.1^{**} (1.8-14.1)	5.5^{**} (2.0-15.1)	5.4^{**} (2.0-15.1)	4.8^{**} (1.8-13.1)
Low-Income Category *(Ref. Category: High Income Category)*	9.3^{**} (4.5-19.3)	6.7^{**} (3.2-14.2)	6.7^{**} (3.1-14.1)	5.3^{**} (2.5-11.2)
Middle-Income Category *(Ref. Category: High Income Category)*	2.2^{*} (1.0-5.0)	2.0^{NS} (0.9-4.6)	2.0^{NS} (0.9-4.5)	1.8^{NS} (0.8-4.0)
Interaction of Low-Income Category and Lower Coherence (Weak SOC)	0.5^{NS} (0.2-1.4)	0.5^{NS} (0.2-1.5)	0.5^{NS} (0.2-1.5)	0.5^{NS} (0.2-1.5)
Interaction of Middle-Income Category and Lower Coherence (Weak SOC)	0.7^{NS} (0.2-2.3)	0.7^{NS} (0.2-2.4)	0.7^{NS} (0.2-2.3)	0.8^{NS} (0.2-2.5)

** P<0.01
* P<0.05
NS: Not Significant

Ref. Category: Reference Category
PR: Prevalence Ratios
SOC: Sense of coherence

a: Model 1 comprised the interactions of SOC with different income groups and the main effects of income and SOC.
b: Model 2 adjusted for sociodemographic variables: sex and age.
c: Model 3 adjusted for all sociodemographic variables: sex, age, the main language spoken at home, and country of birth.
d: Model 4 adjusted for all sociodemographics (sex, age, the main language spoken at home and country of birth) and all health behaviour variables (daily toothbrushing, smoking, dental insurance and last dental visit).

Table S1. The characteristics of the participants in the current study compared to DCOHS respondents and cases excluded due to missing responses

	DCOHS (n=4494) % (95% CI)	Study sample (n=3664) * % (95% CI)	Excluded cases (n= 830) % (95% CI)
Health behaviour variables			
Last Dental Visit			
Within The Past Year	61.1 (51.3-70.2)	61.9 (52.2-71.0)	57.5 (47.7-66.9)
One Year Ago And More	38.9 (29.8-48.7)	38.1 (29.0-47.8)	42.5 (33.1-52.3)
Dental insurance			
With Insurance	66.1 (56.5-74.8)	68.9 (59.4-77.4)	59.2 (49.4-68.5)
Without Insurance	32.2 (23.7-41.8)	31.1 (22.6-40.6)	40.8 (31.5-50.6)
Smoking Status			
Non-Smoker	54.3 (44.5-63.8)	54.5 (44.7-64.0)	53.3 (43.5-62.9)
Former Smoker	33.9 (25.2-	34.3 (25.5-43.9)	32.2 (23.7-41.8)
Current Smoker	11.8 (6.6-19.2)	11.2 (6.1-18.5)	14.5 (8.6-22.4)
Toothbrushing Frequency			
Twice A Day Or More	53.8 (43.4 -	54.9 (45.1-64.4)	48.1 (38.5-57.8)
Less Than Twice Daily	46.2 (36.7-56.0)	45.1 (35.6-54.9)	51.9 (42.2-61.5)
Sociodemographic characteristics			
Country Of Birth			
Australia	78.7 (69.9-85.8)	78.9 (70.2-86.0)	78.0 (69.2-85.2)
Other Countries	21.3 (14.2-30.1)	21.1 (14.0-29.8)	22.0 (14.8-30.8)
Main Language Spoken At Home			
English Speakers	95.5 (90.1-98.4)	95.7 (90.4-98.5)	94.5 (88.7-97.8)
Other Languages	4.5 (1.6-9.9)	4.3 (1.5-9.6)	5.5 (2.2-11.3)
Sex			
Male	44.0 (34.6-53.8)	44.2 (34.7-54.0)	42.9 (33.5-52.7)
Female	56.0 (46.0-65.4)	55.8 (46.0-65.3)	57.1 (47.3-66.5)
Age Groups			
18-45 years	30.0 (21.7-39.5)	31.8 (23.3-41.3)	21.7 (14.5-30.5)
46-60 years	31.5 (23.0-41.0)	32.3 (23.7-41.9)	27.7 (19.7-37.0)
>60 years	38.5 (29.4-48.3)	35.9 (27.0-45.6)	50.6 (40.9 -60.3)

* Based on final analytic sample size comprising cases with non-missing data on all variables in the analysis

Table S2. Characteristics of the current study respondents and population data from the 2016 South Australian Census

	Current study (unweighted) %	Current study (weighted) %	2016 South Australian Census %
Country Of Birth			
Australia	78.9	815	71.1
Other Countries	21.1	18.5	28.9
Sex			
Male	44.2	49.5	49.3
Female	55.8	50.5	50.7
Age Categories			
18-45 years	31.8	48.8	41.7*
46-60 years	32.3	25.7	26.5**
>60 years	35.9	25.5	31.8***
Income Categories			
≤$40,000	29.1	26.8	33.2†
$40,001 - $100,000	41.5	40.8	39.5‡
> $100,000	29.4	32.5	27.2§

* *20-44 years*
** *45-59 years*
*** *≥60 years*

† *≤ $41,599 (<$799/week)*
‡ *$41,600 -$103,999 ($999-$1,999/week)*
§ *≥104,000 (≥$2,000/week)*

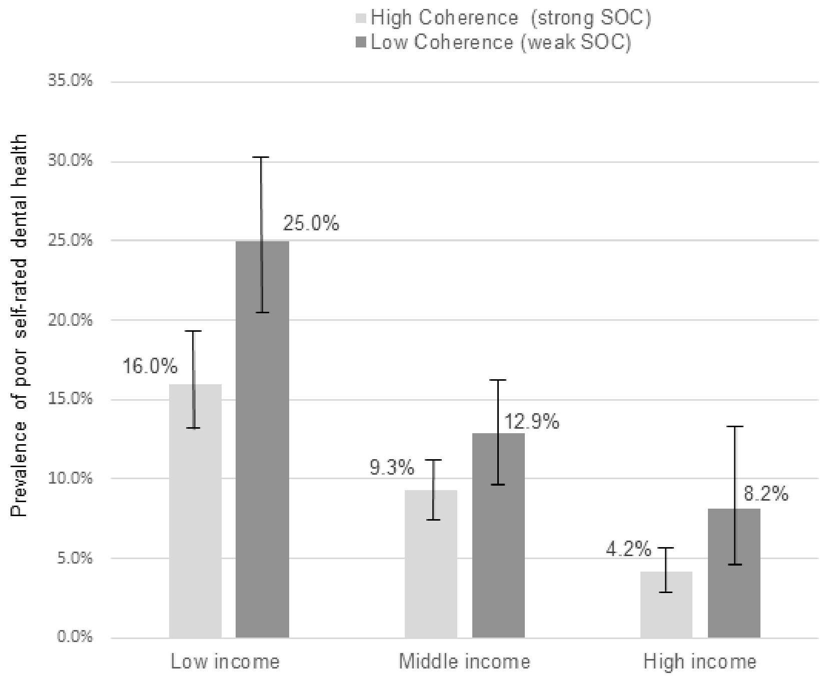

Fig. 1 Poor self-rated dental health by sense of coherence (SOC) and income

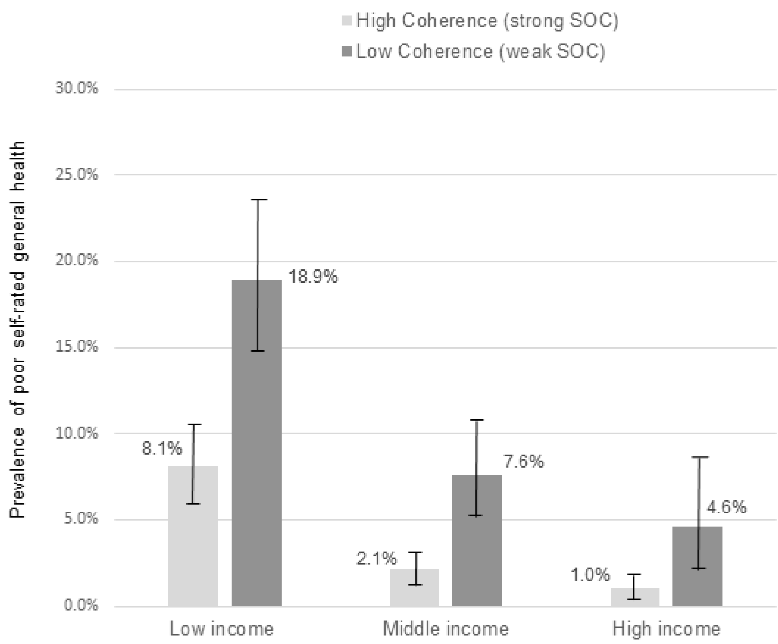

Fig. 2 Poor self-rated general health by sense of coherence (SOC) and income

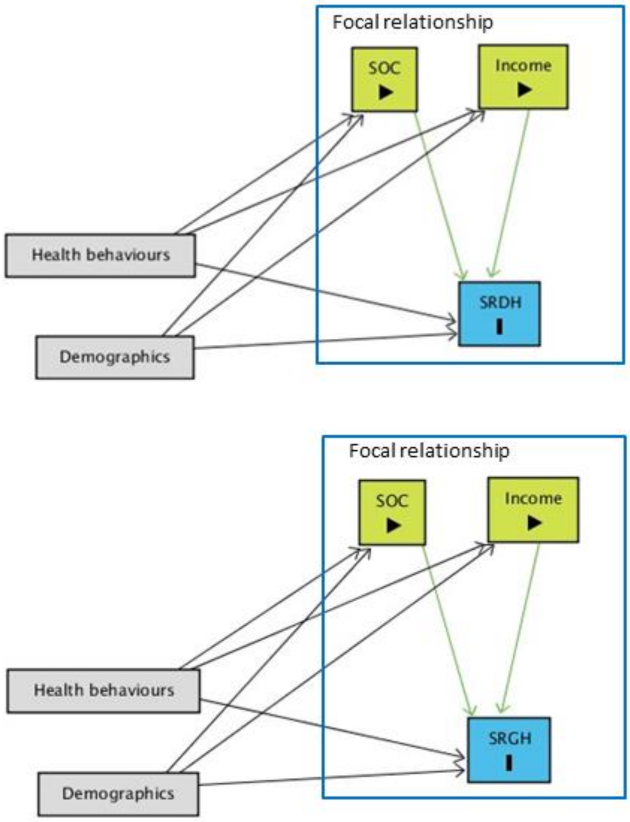

Fig. S1 Directed Acyclic Diagram (DAG) with the focal relationships between the main exposures (sense of coherence (SOC) and income) and the outcome (self-rated dental and general health (SRDH and SRGH, respectively))

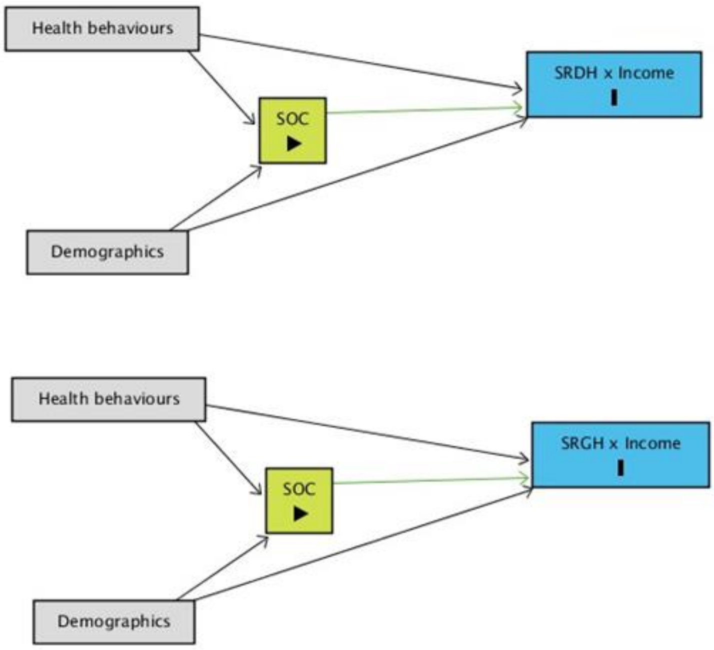

Fig. S2 Direct Acyclic Diagram (DAG) Direct Acyclic Diagram (DAG) with the interaction effect between the main exposures (sense of coherence (SOC) and income)

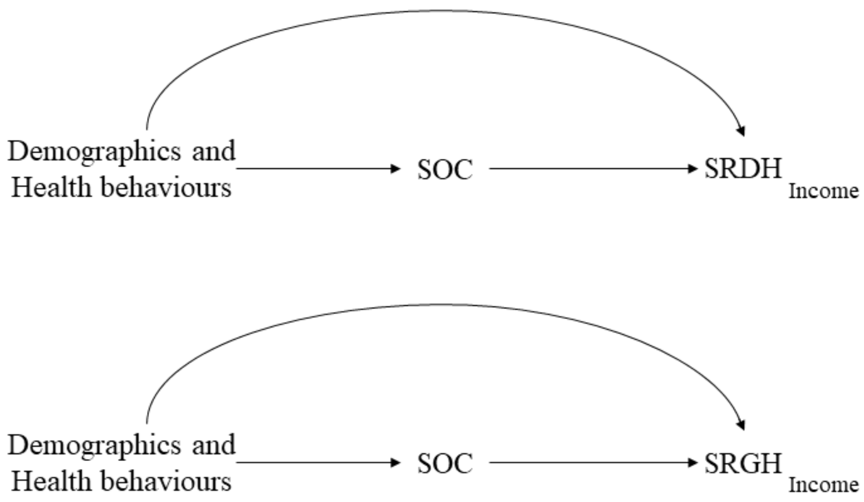

Fig. S3 Interaction Directed Acyclic Diagram (IDAG) of the interaction effect between the main exposures (sense of coherence (SOC) and income)

7 Chapter 7: Effect of personality traits on socioeconomic inequalities in health, a population-based study

7.1 Highlights

- Associations were observed between low scores for conscientiousness and emotional stability with poor self-rated general health (SRGH) and low scores for agreeableness, conscientiousness and extraversion with poor self-rated dental health (SRDH).

- High scores for agreeableness and emotional stability modified the effect of low income on poor SRDH. Also, high conscientiousness scores modified the association between low income and poor SRGH. These findings suggest a more beneficial role of these traits at low-income levels for oral and general health self-ratings than at high-income levels.

- High scores for extraversion, conscientiousness, agreeableness, openness and emotional stability were protective in terms of oral and general health self-ratings at all income levels. In other words, those with high scores for all personality traits had a lower prevalence of poor SRDH and SRGH at all income levels.

7.2 Statement of Authorship

Statement of Authorship

Title of Paper	Effect of personality traits on socioeconomic inequalities in health, a population-based study
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Principal Author

Name of Principal Author (Candidate)	Mehrsa Zakershahrak
Contribution to the Paper	Conceptualisation, design and implementation of research methodology Data analysis, and model design Manuscript writing – original draft preparation Editing and revisions Performing duties as corresponding author
Overall percentage (%)	80%
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature	Date: 22 August 2022

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate in include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	David Brennan
Contribution to the Paper	Conceptualisation and supervision of design and development of research methodology Contributed to model design, data analysis and interpretation of the results Input in the manuscript's writing, editing and revisions
Signature	Date: 7 September 2022

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Study 4: Effect of personality traits on socioeconomic inequalities in health, a population-based study

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Abstract

Objectives: This study aimed to estimate the effects of positive personality traits in income and self-rated dental and general health (SRDH and SRGH) associations in a large South Australian sample.

Methods: Cross-sectional analyses were conducted using self-reported data collected from 3,578 adults in 2015-2016. Multiple variable regression models assessed the main effects and interactions of the Ten-Item Personality Inventory (TIPI) and income with SRDH and SRGH. Prevalence ratios (PR) of poor health ratings were estimated using Poisson regression.

Results: Among all respondents, high-income individuals with stronger Conscientiousness scores had the lowest prevalence of poor SRGH (0.8%), while those with stronger Extraversion (2.9%) and Agreeableness scores (3.4%) had the lowest prevalence of poor SRDH. Poor SRGH was related to weak Conscientiousness (PR=6.9, 95% CI[2.3-20.8]) and Emotional Stability scores (PR=6.0, 95% CI[2.0-18.3]), while poor SRDH was associated with weak Extraversion (PR=2.3, 95% CI[1.2-4.5]), Agreeableness (PR=1.8, 95% CI[1.0-3.2]) and Conscientiousness scores (PR=2.1, 95% CI[1.1-4.0]). Among low-income people, poor health ratings were less prevalent in those with stronger positive personality trait scores versus weaker scores. Among low-income respondents, poor SRGH was lower in individuals with stronger versus weaker Conscientiousness scores (10.9% vs 16.2%), and poor SRDH showed lower prevalence in participants with stronger versus weaker Agreeableness scores (18.1% vs 22.6%).

Conclusion: Findings showed the association between personality traits and the prevalence of poor SRDH and SRGH. Stronger positive personality traits modified the

self-rated health inequalities associated with low income in a representative sample of the South Australian population.

Keywords: socioeconomic inequalities, personality, self-rated health, subjective health

Introduction

Income-related social gradients in self-rated oral and general health have been reported, which show lower socioeconomic status (SES) is associated with a higher prevalence of poorer oral and general health [1]. However, one critical question remains: Why do some people seem able to avoid poor health despite being subjected to severe stressors of SES adversity? Studies have shown that not everyone from low SES necessarily has poor health [2,3]. According to the biopsychosocial model, the interaction between chronic stressors (e.g., low SES) with psychosocial factors could cause stress-related biological responses (e.g., inflammatory and hormonal responses) that adversely affect health [4]. Positive psychosocial factors are shown to enhance the ability to cope effectively with stress [5]. Individuals with effective coping strategies can better cope with the chronic stress of low-SES situations because of their personality traits [6]. Therefore, stress-coping management might be a valuable psychological resource for low-SES people with limited resources [7]. Psychological factors could buffer the adverse effects of low SES in health [2].

Researchers have used the Big Five personality theory to explain why people behave the way they do by relating personality dimensions in shaping their behaviours. Based on this theory, the five dimensions that make up personality are Extraversion, Agreeableness, Conscientiousness, Openness to experience and Emotional Stability (opposite to Neuroticism) [8]. The association between personality traits and single-item global self-ratings of health has been reported [9], which links poor self-rated health (SRH) with high Neuroticism (low Emotional Stability, the tendency to have negative emotions, anxiety and stress) has been stated [9]. Conscientiousness (being organised and self-disciplined) and Extraversion (being energetic, social, and having positive emotions) are positively associated with SRH [9]. Evidence for Agreeableness (trust, altruism, and being cooperative) and Openness (curiousness and unconventionality) is mixed (positive, negative and no effects) [9].

An individual's oral health is associated with their general health [10]. Also, oral and general health have common risk factors [10], and both are affected by personality traits in similar ways (health-related behaviours and how individuals interpret and react to symptoms) [11,12]. One of the most common measures for assessing general and oral health status is single-item global self-ratings [13]. They allow individuals to integrate their interpretation of the different health dimensions [13]. These non-clinical measures have been effective in predicting mortality and morbidity, as clinical trials' endpoints and high-risk groups' screening [13] and comparing oral and general health perceptions [14]. According to the Wilson and Cleary model of health-related quality of life (HRQOL) [15], these measures are conceptually considered as general health perceptions [14]. Their model proposes a link between an individual's characteristics (such as personality) and health and quality of life [15]. This model explains the relationship between "patient-specific factors" like personality and general health perceptions (self-rated one-item dental and general health measures) [15]. However, there is a lack of large-scale cross-sectional studies for assessing the modifying effect of personality traits in the SES gradients in health outcomes and their interactions with income in health. Effect modification occurs when the exposure's effect differs across the other exposure's strata. Interaction is the combined effect of both exposures on the outcome [16].

Thus, this research aimed to estimate the modifying effect of the positive personality traits in the association of income and self-rated dental and general health (SRDH and SRGH) using a representative South Australian population sample. The hypotheses were: 1- low income and low scores for each personality trait would be associated with the highest prevalence of each poor health outcome measure (SRDH and SRGH); 2- interactions between income and low scores for personality traits would be observed; and 3- in low-income individuals, those with high scores for each positive personality trait would have a lower prevalence of each poor health outcome measure (SRDH and SRGH) than those with low scores for a personality trait.

Methods

The sample was drawn from the baseline data of the Dental Care and Oral Health Study (DCOHS). DCOHS is a comprehensive cohort study. In 2015, a random sample of 12,245 adults aged 18 years and older drawn from the South Australian Electoral Roll were invited by mail to participate in the study voluntarily and confidentially. The questionnaires with three reminder follow-ups mailings were sent to them. The University of Adelaide Human Research Ethics Committee approved the research (H-288-2011). The data were weighted using the estimates of the South Australian population's age and sex distribution from the Australian Bureau of Statistics [17,18].

The outcome variables were self-rated dental health and general health, measured using the single-item global ratings on 5-point Likert scales, comprised the questions "How would you rate your general health?" and "How would you rate your dental health?". These valid measures provide a subjective perception of oral and general health [19,20]. Based on previous studies [21, 22], the responses were dichotomised as those who reported good, very good or excellent dental and general health and others with poor to very poor SRDH and SRGH. The reference category was respondents who rated their SRDH and SRGH as good to excellent.

The main explanatory variable was total household income before tax (in Australian Dollars), collected in 10 categories of $20,000 (from <$20,000 to >$180,000). To have an estimated even distribution, we coded income into three approximately equal-sized categories (approximate tertiles) using a distributional approach (0-$40,000, $40,001-$100,000 and more than $100,000). By using this approach, the low-income level can be compared with medium and high-income levels, regardless of the actual level of income (thresholds). Also, the actual income level could lose its meaning over time (e.g., because of economic factors such as inflation). However, by using tertiles the interpretation remains the same. Additionally, the distribution approach can be used to evaluate the income gradient in health, allowing the assessment of potential "dose-response" effects.

The effect modifiers were the Big Five personality traits as the psychosocial factors assessed by the Ten-Item Personality Inventory (TIPI). TIPI is a brief self-reported test, which Gosling [23] designed to evaluate the Big Five personality traits using two options for each trait. In each dimension, one item is reversed. Each item was reported on a 7-point Likert scale (1= Disagree Strongly to 7= Agree Strongly). The responses to the five reversed items were coded reversely to match the standard items. The average of related standard and reverse-coded items were used for each dimension's score (a higher score represented a greater propensity to exhibit that trait). Each TIPI scale (ranging from 1 to 7) was dichotomised based on the conceptual approach (splitting the scale based on a score equivalent to being "agree" or higher) as lower TIPI (<5 reflecting disagree) and higher TIPI (5-7 reflecting agree) [24].

The other explanatory variables (conceptually related covariates) were added to the models to cover the different dimensions of socio-demographic characteristics (age, sex, the main language spoken at home and birthplace) and health behaviours (dental insurance, smoking status, daily tooth brushing and last dental visit). Age (collected as continuous data) was coded into age groups of 18-45, 46-60, and 61 years and more to produce an approximately equal distribution. Birthplace was collected as those born in

Australia or other countries and categorised accordingly. Dental insurance (collected by asking, "What best describes your private health insurance status?") was dichotomised as those with dental insurance and those without. The main language spoken at home was collected as English speakers and those who spoke other languages and grouped the same way. Smoking status was collected as "I smoke daily", "I smoke occasionally", "I do not smoke now but I used to" and "I have never smoked", and categorised into: current, former and non-smokers. Daily tooth brushing (collected as the frequency per day) was classified as those who brushed their teeth twice a day or more or respondents who brushed less than that. The six ordinal levels of the last dental visit being "<12 months ago", "1 to <2 years ago", "2 to <5 years ago", "5 to <10 years ago", ≥10 years" and "Never attended" were dichotomised as individuals who visited the dentist less than a year ago and others with the previous dental visit one year ago or later.

Unadjusted associations of SRDH and SRGH were assessed by the explanatory variables and effect modifiers, followed by the evaluation of associations with personality trait dimensions (TIPI) stratified by household income categories. Multiple variable Poisson regression models assessed the adjusted associations between SRDH and SRGH with TIPI dimensions and income categories. Initially, the associations between income and each TIPI dimension with SRDH and later SRGH (model 1) were examined, along with the main effect and interaction of income and each TIPI dimension. Then, conceptually related covariates comprising socio-demographic characteristics and health behaviours were added in successive blocks. In models 2 to 4, model 1 analyses were adjusted for: Model 2 was adjusted for sex and age; Model 3 was adjusted for sex, age, the main language spoken at home and place of birth; Model 4 was adjusted for analyses from model 3 and also daily tooth brushing, smoking, dental insurance and last dental visit. These four models evaluated whether each TIPI dimension modified the associations between both outcomes (separately) and income by fitting interaction terms and descriptively examining their stratified effects. All four models of each outcome fit the data based on Pearson Chi-Square (Value/df>0.05).

The Poisson regression models with robust error variance (to correct for overdispersion) allowed us to calculate Exponential Beta to show the prevalence ratio (PR). PR is an accurate measure to estimate effect size for cross-sectional studies [25].

Respondents who answered all TIPI, SRGH, SRDH, and income questions (complete cases, n=3,798) were used for the analyses. Other variables' missing cases (n=220) were excluded from the Poisson regression, giving us the final sample size of n=3,578 for the models. We compared the final sample with respondents with missing responses to determine whether the final sample differed from excluded cases (response bias). Also, another comparison using the census data was performed to assess the representativeness of the final sample. The large sample size available for analysis provided adequate statistical power despite some reduction in sample size due to missing data. The sample size calculations for DCOHS were based on oral health outcomes estimates from the National Survey of Adult Oral Health (NSAOH) in Australia and a power of 80% (significance level α=0.05) [17]. Also, for the final sample, power was calculated using SPSS and G*Power 3.1.9.7 at a significance level $\alpha = 0.05$. All analyses were performed in the SPSS software version 28 (IBM Corp.), with 95% confidence intervals.

Results

A total of 4,494 responses were received. The response rate was calculated at 44.8% after omitting the out-of-scope sample cases (non-contacts due to the change of residential address). Table 1 details the descriptive statistics of SRDH and SRGH by the study sample characteristics of the 3,578 individuals 18 to 86 years old in DCOHS, and 95% CIs were used to assess unadjusted associations. The prevalence of poor SRDH and SRGH was 11.3% and 5.4%, respectively. The participants who had the lowest prevalence of poor SRDH and SRGH were from the 18-45 years age group, were non-smokers, brushed their teeth twice or more daily and had dental insurance.

Table 2 shows that respondents with greater personality trait scores had lower rates of poor SRDH and SRGH. A significant gradient across income groups was observed, and high-income (>$100,000) respondents had the lowest prevalence of poor SRDH and SRGH.

The comparison of the study sample with excluded cases (Table S1) showed similar compositions with minor differences in health behaviours (last dental visit, dental insurance, and tooth brushing) and age groups of 18-45 and over 60 years old. However, these small differences were statistically significant for young and old age groups and dental insurance.

The comparison of the final sample with the population data (Table S2) indicated that the final sample was broadly representative of the South Australian population. However, there were higher percentages born in other countries, over 60 years old and low income in census data.

For parsimony, only model 4 (the fully adjusted model) is presented in detail, while all the other models were generally consistent and are included as supplementary tables S3 to S8. Also, for the final sample, a power of 1.00 was observed for all models. Middle and low household income were significantly associated with poor dental health for all personality dimensions (Table 3). Weak Agreeableness (PR=1.8), Extraversion (PR=2.3) and Conscientiousness scores (PR=2.1) were significantly associated with poor SRDH, and these traits' higher PRs showed their greater effect for SRDH. The interaction effect of weaker Extraversion at lower income had a lower PR (PR=0.4), indicating a relatively greater effect for Extraversion at higher income (reflecting the lower prevalence of poorer SRDH for high-income respondents with stronger Extraversion scores) (Table 3 and Figure 1-A). The lower PR (PR=0.6) for the interaction effect of weak Agreeableness with middle income revealed a relatively greater impact of Agreeableness at high income, representing the lower rates of poor SRDH among those with stronger Agreeableness scores and high income.

Low income was also significantly associated with poor general health for all personality dimensions (Table 4). In contrast, middle income was only significantly associated with poor SRGH for Conscientiousness (PR=3.3). There was a higher prevalence of poor SRGH among those with weak Conscientiousness and weak Emotional Stability scores, and the higher PR of these traits indicated their greater associations (effects) with SRGH. The lower PR (PR=0.2) for the interaction of weaker Conscientiousness at lower income indicated a relatively greater effect for Conscientiousness at the higher income, reflecting the lower prevalence of poorer SRGH for high-income individuals with stronger Conscientiousness scores.

In low-income individuals, those with stronger Agreeableness scores (18.1%) had a lower prevalence of poor SRDH than others with weaker Agreeableness scores (22.6%) (Figure 1-B). Also, in low-income respondents, a lower prevalence of SRDH was observed in those with strong Emotional Stability (13.6%) than others with weak scores (25.0%) (Figure 1-C). Among low-income respondents, those with strong Conscientiousness (10.9%) had a lower prevalence of poor SRGH than those with weaker Conscientiousness scores (16.2%) (Figure 1-D). Low-income respondents had a greater absolute difference in the prevalence of poor SRDH between those with weak and strong Emotional Stability

(11.4% vs 1.0%) and Agreeableness (4.5% vs 3.8%) scores than high-income respondents. There was a smaller difference in the prevalence of poor SRGH between those with weak and strong Conscientiousness scores than high-income respondents (5.3% vs 4.4%) (Figure 1-D).

Discussion

Weak Conscientiousness and Emotional Stability scores were associated with poor SRGH. Except for Emotional Stability and Openness, poor SRDH was more prevalent in those with weaker scores on personality traits (all models). Low income was consistently associated with poorer SRGH and SRDH in all models. Interactions between low-income and weak Conscientiousness scores with SRGH (all models) were observed. Findings revealed there were significant interactions of low-income and weak Extraversion scores (all models) and middle-income and weak Agreeableness scores (in the fully adjusted model) with SRDH.

Congruent with previous findings [26], Extraversion and Agreeableness had similar associations (effects) with poor oral health. The strongest associations (effects) were found between low Conscientiousness and Emotional Stability with poor SRGH, consistent with previous research showing that individuals with high levels of irresponsibility and emotional instability report poorer general health [27]. Also, poor SRDH was more prevalent than poor SRGH in our population sample. Although oral and general health are closely linked [10], they are often approached differently (i.e., separate education and treatment for oral and dental problems from the rest of the body), as well as having different related health services (e.g., separate insurance cover; only general health is universally covered in Australia) [28].

The combined effects (interaction effects) of strong personality traits and high income were associated with the lowest prevalence of poor SRDH and SRGH (among high-income respondents with strong personality traits). However, the modifying effects of strong Emotional Stability and Agreeableness scores in the association between low-income and poor SRDH suggest potentially greater health benefits in terms of the size of absolute differences in the prevalence of stronger scores of these traits for low-income respondents than for high-income respondents. Also, strong Conscientiousness scores modified the association between low-income and poor SRGH, showing that strong Conscientiousness conferred greater health benefits in the size of differences in prevalence to the low-income group than the high-income group. The findings suggest greater opportunities for low-income people to improve their oral and general health through interventions that target these traits. Similarly, previous studies have underlined the importance of personality traits as protective psychosocial factors for low-SES groups [6,29-31]. Social adversity affects the health of those with personality traits related to poorer health outcomes more than others [29]. Personality significantly affects healthy behaviours (healthy eating) in low-SES groups [30]. Also, coping flexibility could be a moderator of the SES-HRQOL relationship [6], which is a crucial resource for low-SES people in adaptability to a stressful life. Besides, psychosocial factors can buffer the unfavourable effect of low SES in health disparities [6]. Consistent with our findings, Conscientiousness has been suggested as a beneficial health factor for low-SES groups [31].

This study used personality traits as the explanatory variables rather than clinical case definitions. By dichotomising individuals, we were able to determine where they fell on the personality spectrum (expressing the trait at a high or low level); i.e., shift the focus from the homogeneity of personality traits (as variables) to individual differences (as participants) [32]. Thus, we were able to compare how the association between the exposure (income) and outcomes (poor SRDH and SRGH) differed across the different effect modifier categories (greater versus lower personality traits) [16]. The advantages of categorizing the exposure (assessing the effects of each exposure level separately without limitation) outweigh the potential disadvantages (reduced statistical power, loss of some information, and requiring additional terms in the model) [33]. The risk of such errors is negligible when large sample size is analysed (such as in the present study). Also, VanderWeele et al. [34] argued that dichotomisation has the advantage of avoiding model misspecification in interaction analyses.

The covariates in our study were selected based on the general concept of health behaviours to cover their different dimensions without overlapping. Each represents a conceptual factor: preventive behaviours (tooth brushing), risky behaviours (smoking), health service utilisation (last dental visit), and enabling factors (dental insurance). Such variables rarely occur separately, rather they tend to cluster together [35,36]. Also, in social and behavioural science, no model can encompass all relevant predictors of outcome [37]. Models should include covariates that provide unique information (to maximize their predictive value) while avoiding multicollinearity (having too few or too many variables) or overlap [38]. It is important to avoid correlated covariates since they increase the standard error of the estimated regression coefficients [39]. Limiting the covariates to the most important ones simplifies interpretation and multiple testing [39]. Additionally, it prevents overfitted models, which have poor predictions despite their good fit [39].

Given that tackling SES-health inequalities through broader SES-targeted interventions and anti-poverty social policies could be challenging, better health outcomes for low-SES individuals can be achievable by strengthening psychosocial factors related to better health. This empowerment approach could include personality interventions (by targeting personality traits linked with risky behaviours) [40] and community-based interventions that use positive psychology among poor individuals [41], and mental health promotion [42]. Other holistic health-promotion approaches (such as the WHO healthy city project by providing psychological resources and developing mental health-enhancing places [43]) can provide supportive environments for vulnerable populations. Also, behavioural change interventions have shown promising results in promoting oral health behaviours [44]. A debate has raged over whether personality changes persist over time or revert and whether these interventions actually work at a population level. These interventions are congruent with the personality development framework (short-term situational processes lead to long-term personality changes) [45]. The cumulative effect of small changes in a trait's expression over time changes the level of that trait in two general ways: as reflective and associative processes [45]. The reflective process involves consciously collecting information from observing and analysing one's behaviour, feelings, perceptions and thoughts. It is assumed that this process affects the individual's personality and helps maintain it. Alternatively, personality development could result from associative learning, such as habit formation without reflecting (i.e., frequent repeating of behaviour leads to habitual behaviour). While some evidence supports the effectiveness of psychological interventions at the population level [41,42,46], their practical implications seldom lead to changes at the population level. Three factors contributed to the failed translation of their sustainability and long-term success: short implementation of these interventions at the community/population level, lack of funding, and failure because of over scaling and implementation problems (poor management) [46]. Thus, to reduce vulnerability to social stressors and promote health in low-income groups, upstream factors and long-term community-based programs with proactive mental health approaches should be emphasised with adequate funding and effective management.

SRDH and SRGH are valid and reliable patient-centred measures. In other words, the individual's perception and interpretation of their health (subjective health) are central to their quality of life [11] and strongly influence their health-related behaviours [47]. People tend to continue their current lifestyles when they rate their health as "good" [47]. Meanwhile, certain personality traits affect subjective health [11]. Personality traits can affect subjective health through affectivity (positive or negative perceptions based on one's personality) and can influence objective health (professional assessment) through healthy behaviours. Individuals with strong Extraversion, Conscientiousness, Openness and Agreeableness engage in physical activities and health-promoting behaviours, leading not only to positive evaluations of SRDH and SRGH but also better objective health [9]. While weak Emotional Stability (Neuroticism) is associated with poor subjective health (negative perception of health ratings), it is also associated with poor objective health (poor health behaviours and many health problems) [9,11]. Therefore, the following factors should be considered when interpreting the present study's findings from a multidimensional perspective of health: 1- Those with negative affectivity are influenced to a greater extent by their objective health, thereby negatively affecting their subjective health ratings [11]; 2- The subjective health ratings of those with negative affectivity are more accurate given their greater awareness and sensitivity of their objective health [11]; 3- Positive psychological characteristics could affect health independent of symptoms and positive affectivity [9].

Strengths of the study include: using the large South Australian representative sample, analysing data with four models that incorporate adjustment for various variables, using valid and standard self-ratings for health and personality traits, and evaluating oral and general health outcomes for any consistent patterns across both outcomes. Limitations comprise the low response rate of 44.8%. However, response rates below 50% were common for surveys over the past thirty years. Congruent with the latest comparisons [17,18], DCOHS broadly represented the age and gender distribution of South Australian adults, considering it was derived from an extensive sampling frame (Electoral Roll). The final sample was also representative of the general population, with slight differences, possibly because of the different categorisation of income and age in census data. Additionally, the final sample was similar to the excluded respondents, resulting in minimal response bias.

Conclusion

Findings showed cross-sectional associations between personality traits and income-health inequalities. There were associations between weaker scores for some personality traits and the prevalence of poor SRDH and SRGH. Interactions of weaker scores of Extraversion, Agreeableness and Conscientiousness with low and middle-income were associated with health ratings. The findings contribute to a growing body of literature on the association between personality traits and health outcomes and SES-health inequalities. Improving psychological factors to cope with the stress of low-SES conditions can provide a practical method for reducing SES-health inequalities.

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Table 1. Self-rated dental and general health by study characteristics

	Distributions *	SRDH Poor to very poor		SRGH Poor to very poor	
	N (%)	N (%)	95% C.I.	N (%)	95% C.I.
Total Sample (n=3578)		406 (11.3%)	10.3-12.5	194 (5.4%)	4.7-6.2
Health behaviour variables					
Last Dental Visit					
Less Than A Year Ago	2226 (62.2%)	186 (8.4%)	7.2-9.6	96 (4.3%)	3.5-5.3
More Than A Year Ago	1352 (37.8%)	220 (16.3%)	13.9-18.3	98 (7.2%)	5.9-8.8
Dental insurance					
Insured	2478 (69.3%)	193 (7.8%)	6.7-8.9	93 (3.8%)	3.0-4.6
Uninsured	1100 (30.7%)	213 (19.4%)	16.8-22.1	101 (9.2%)	7.5-11.2
Cigarette Smoking					
Non-Smoker	1942 (54.4%)	148 (7.6%)	6.4-8.9	73 (3.8%)	2.9-4.7
Former Smoker	1233 (34.4%)	146 (11.8%)	10.0-13.9	88 (7.2%)	5.7-8.8
Current Smoker	403 (11.3%)	112 (27.8%)	22.9-33.4	33 (8.2%)	5.6-11.5
Tooth Brushing					
Twice A Day Or More	1964 (54.9 %)	138 (7.0%)	5.9-8.3	74 (3.8%)	3.0-4.7
Less Than Twice A Day	1614 (45.1%)	268 (16.6%)	14.7-18.7	120 (7.4%)	6.2-8.9
Socio-demographic characteristics					
Birthplace					
Australia	2823 (78.9%)	299 (10.6%)	9.4-11.9	129 (4.6%)	3.8-05.4
Other	755 (21.1%)	107 (14.2%)	11.6-17.1	65 (8.6%)	6.7-11.0
Main Language Spoken At Home					
English	3427 (95.8%)	381 (11.1%)	10.0-12.3	176 (5.1%)	4.4-6.0
Other	151 (4.2%)	25 (16.6%)	10.7-24.4	18 (11.9%)	7.1-18.8
Sex					
Male	1598 (44.4 %)	219 (13.8%)	11.9-15.6	110 (6.9%)	5.7-8.3
Female	1989 (55.6%)	187 (9.4%)	8.1-10.9	84 (4.2%)	3.4-5.2
Age Groups (Mean= 52.7)					
18-45 years	1151 (32.3%)	94 (8.1%)	6.6-10.0	33 (2.9%)	2.0-4.0
46-60 years	1159 (32.4%)	145 (12.5%)	10.6-14.7	60 (5.2%)	3.9-6.7
61 years and older	1264 (35.3%)	167 (13.2%)	11.3-15.4	101 (8.0%)	6.5-9.7

* The final sample size used for the analysis, including all variables with non-missing data

Table 2. Self-rated dental and general health by personality dimensions and income

	Distributions *	SRDH Poor to very poor		SRGH Poor to very poor	
	N (%)	N (%)	95% C.I.	N (%)	95% C.I.
Total Sample (n=3578)		406 (11.3%)	10.3-12.5	194 (5.4%)	4.7-6.2
TIPI dimensions					
Extraversion					
Higher	1278 (64.3%)	113 (8.8%)	7.3-10.6	37 (2.9%)	2.0-3.9
Lower	2300 (35.7%)	293 (12.7%)	11.3-14.3	157 (6.8%)	5.8-8.0
Openness					
Higher	2077 (58.0%)	207 (10.0%)	8.7-11.4	76 (3.7%)	2.9-4.6
Lower	1501 (42.0%)	199 (13.3%)	11.5-15.2	118 (7.9%)	6.5-9.4
Agreeableness					
Higher	2300 (64.3%)	246 (10.7%)	9.4-12.1	115 (5.0%)	4.1-6.0
Lower	1278 (35.7%)	160 (12.5%)	10.4-14.3	79 (6.2%)	4.9-7.7
Conscientiousness					
Higher	2897 (81.0%)	283 (9.8%)	8.7-11.0	126 (4.3%)	3.6-5.2
Lower	681 (19.0%)	123 (18.1%)	15.1-21.6	68 (10.0%)	7.8-12.7
Emotional Stability					
Higher	2010 (56.2%)	179 (8.9%)	7.6-10.3	59 (2.9%)	2.3-3.9
Lower	1568 (43.8%)	227 (14.5%)	12.6-16.5	135 (8.6%)	7.2-10.2
Income Groups					
High (> $100 000)	1066 (29.8%)	52 (4.9%)	3.6-6.3	15 (1.4%)	0.8-2.3
Middle ($40 001 - $100 000)	1483 (41.4%)	153 (10.3%)	8.8-12.1	54 (3.6%)	2.7-4.7
Low (≤ $40 000)	1029 (28.8%)	201 (19.5%)	16.9-22.4	125 (12.1%)	10.1-14.5

TIPI: The Ten-Item Personality Inventory
* The final sample size used for the analysis, including all variables with non-missing data

Table 3. Prevalence ratios from the fully adjusted model[1] (Model 4) of SRDH

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
TIPI dimension *(ref. Category: Greater trait score)*	2.3 (1.2-4.5)	1.2[NS] (0.7-2.3)	1.8 (1.0-3.2)	2.1 (1.1-4.0)	1.0 [NS] (0.6-1.7)
Low-Income Group *(ref. Category: High-Income group)*	4.3 (2.3-8.0)	2.4 (1.4-4.0)	2.9 (1.7-4.9)	2.7 (1.7-4.2)	1.7 (1.1-2.8)
Middle Income Group *(ref. Category: High-Income group)*	2.5 (1.3-4.6)	1.8 (1.1-2.9)	2.2 (1.3-3.6)	1.8 (1.2-2.7)	1.7 (1.1-2.6)
Interaction of Low-Income Group and Weak TIPI Dimension	0.4 (0.2-0.9)	0.9[NS] (0.5-1.8)	0.7[NS] (0.3-1.3)	0.6[NS] (0.3-1.1)	1.2 [NS] (0.6-2.2)
Interaction of Middle-Income Group and Weak TIPI Dimension	0.6[NS] (0.3-1.2)	0.8[NS] (0.4-1.6)	0.6 (0.3-1.2)	0.7[NS] (0.3-1.5)	0.9[NS] (0.5-1.9)

NS: Not Significant
ref. Category*:* Reference Category
PR: Prevalence Ratios
TIPI: The Ten-Item Personality Inventory
1: Model 4 adjusted for Socio-demographic characteristics (sex, age, main language spoken at home and birthplace) and Health behaviour variables (daily tooth brushing, smoking status, dental insurance and last dental visit).

Table 4. Prevalence ratios from the fully adjusted model[1] (Model 4) of SRGH

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
TIPI dimension *(ref. Category: Greater trait score)*	2.0^{NS} (0.6-6.8)	1.9^{NS} (0.4-3.4)	0.9^{NS} (0.3-2.7)	6.9 (2.3-20.8)	6.0 (2.0-18.3)
Low-Income Group *(ref. Category: High-Income group)*	4.8 (1.6-14.7)	5.6 (2.6-12.3)	5.2 (2.1-12.5)	10.5 (4.6-24.0)	9.3 (3.6-24.3)
Middle-Income Group *(ref. Category: High-Income group)*	2.5^{NS} (0.8-8.2)	1.8^{NS} (0.8-4.1)	1.5^{NS} (0.6-3.9)	3.3 (1.4-7.7)	2.4^{NS} (0.9-6.7)
Interaction of Low-Income Group and Weak TIPI Dimension	1.1^{NS} (0.3-4.0)	0.9^{NS} (0.3-3.0)	1.2^{NS} (0.4-3.7)	0.2 (0.1-0.6)	0.4^{NS} (0.2-1.3)
Interaction of Middle-Income Group and Weak TIPI Dimension	0.7^{NS} (0.2-3.1)	1.3^{NS} (0.4-4.5)	2.0^{NS} (0.6-6.8)	0.3^{NS} (0.1-1.1)	0.7^{NS} (0.2-2.6)

NS: Not Significant
ref. Category*:* Reference Category
PR: Prevalence Ratios
TIPI: The Ten-Item Personality Inventory
1: Model 4 adjusted for Socio-demographic characteristics (sex, age, main language spoken at home and birthplace) and Health behaviour variables (daily tooth brushing, smoking status, dental insurance and last dental visit).

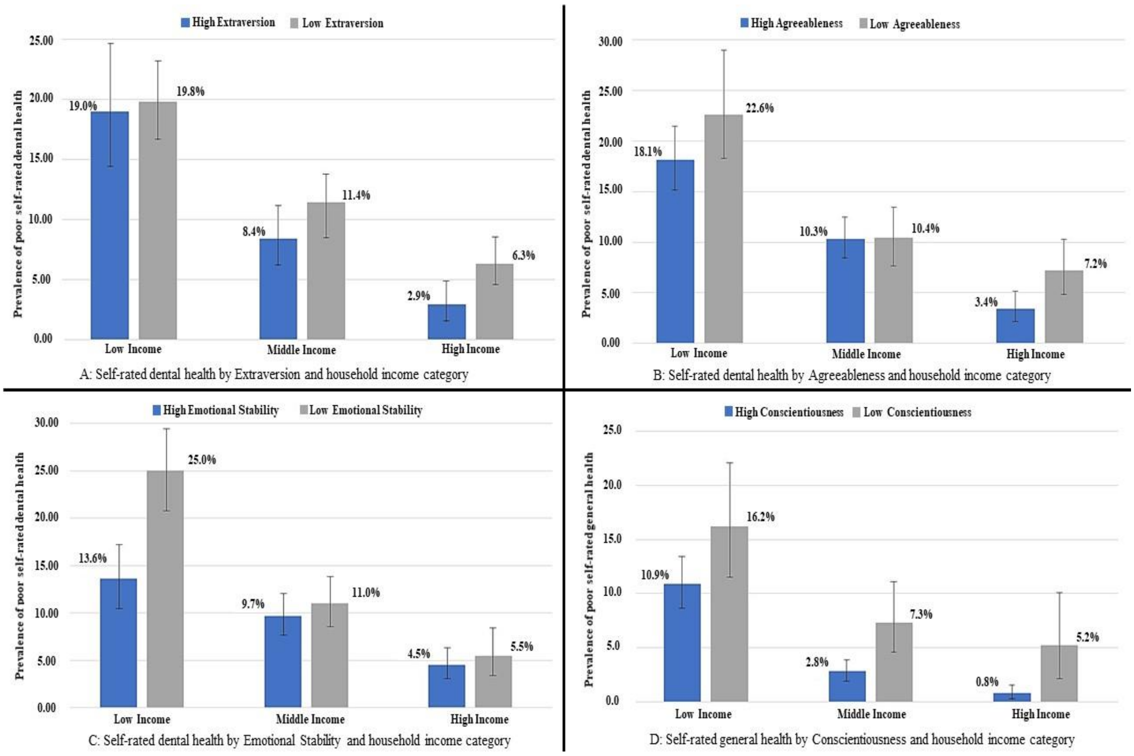

Figure 1: Poor self-rated dental and general health by personality traits and household income category (A: Poor self-rated dental health by Extraversion; B: Poor self-rated dental health by Agreeableness; C: Poor self-rated dental health by Emotional Stability; D: Poor self-rated general health by Conscientiousness)

Table S1. Comparison of characteristics of study respondents with DCOHS and excluded respondents

	Final study sample (n=3578)*	DCOHS (n=4494)	Excluded respondents (n= 916)
	% (95% CI)	% (95% CI)	% (95% CI)
Health behaviours			
Last Dental Visit			
Less Than A Year Ago	62.2 (59.6-64.8)	61.1 (58.8-63.4)	56.6 (51.7-61.7)
A Year Ago And More	37.8 (35.8-39.9)	38.9 (37.1-40.8)	43.4 (39.2-48.0)
Dental insurance cover			
Insured	69.3 (66.6-72.0)	67.2 (64.8-69.7)	58.6 (53.5-64.0)
Uninsured	30.7 (28.9-32.6)	32.8 (31.1-34.5)	41.4 (37.2-46.0)
Cigarette Smoking			
Non-Smoker	54.4 (51.9-56.7)	54.3 (52.2-56.5)	54.5 (49.6-59.7)
Former Smoker	34.4 (32.6-36.4)	33.9 (32.2-35.7)	31.6 (27.9-35.6)
Current Smoker	11.3 (10.2-12.4)	11.8 (10.8-12.8)	13.9 (11.6-16.7)
Daily Tooth Brushing			
Twice A Day Or More	54.9 (52.5-57.4)	53.8 (51.6 -56.0)	48.7 (43.9-53.8)
Less Than Twice A Day	45.1 (42.9-47.4)	46.2 (44.2-48.3)	51.3 (46.4-56.6)
Sociodemographic			
Birthplace			
Australia	78.9 (76.0-81.9)	78.7 (76.1-81.4)	78.0 (72.1-84.3)
Other Countries	21.1 (19.6-22.6)	21.3 (19.9-22.7)	22.0 (18.9-25.5)
Main Language Spoken At Home			
English	95.8 (92.6-99.0)	95.5 (92.6-98.4)	94.1 (92.3-95.6)
Other	4.2 (3.6-4.9)	4.5 (3.9-5.2)	5.9 (4.5-7.9)
Sex			
Male	44.4 (42.4-46.8)	44.0 (42.0-46.0)	42.2 (38.1-46.7)
Female	55.6 (53.2-58.1)	56.0 (53.9-58.3)	57.8 (52.9-62.9)
Age Groups			
18-45 years	32.3 (30.3-34.1)	30.0 (28.4-31.6)	20.9 (18.0-24.0)
46-60 years	32.4 (30.6-34.3)	31.5 (29.9-33.1)	27.8 (24.5-31.5)
≥61 years	35.3 (33.4-37.3)	38.5 (36.8-40.4)	51.3 (46.8-56.2)

* The final sample size used for the analysis, including all variables with non-missing data
DCOHS: the Dental Care and Oral Health Study (the main dataset)

Table S2. The characteristics of the study respondents compare to the general population

	Final study sample [1]	Final study sample (weighted) [1]	2016 South Australia Census data
Demographics (%)			
Place of Birth			
Australia	78.9	81.5	71.1
Other	21.1	18.5	28.9
Sex			
Male	44.4	49.8	49.3
Female	55.6	50.2	50.7
Age Groups			
18-45 years	32.3	49.4	41.7*
46-60 years	32.4	25.7	26.5**
61 years and older	35.3	24.9	31.8***
Income Groups (%)			
0-$40,000	28.8	26.5	33.2†
> $40,000 - $100,000	41.4	40.8	39.5‡
More than $100,000	29.8	32.7	27.2§

1: The final study sample size used for the analysis, including all variables with non-missing data

** 20-44 years*
*** 45-59 years*
**** 60 years and older*

† ≤ $41,599 (<$799/week)
‡ $41,600 -$103,999 ($999-$1,999/week)
§ ≥ $104,000 (≥$2,000/week)

Table S3. Prevalence ratios from crude model[1] (Model 1) of SRDH

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
TIPI dimension *(ref. Category: Greater trait score)*	2.7 (1.4-5.2)	1.4[NS] (0.8-3.0)	2.0 (1.1-3.7)	2.7 (1.4-5.1)	1.2[NS] (0.7-2.3)
Low-Income Group *(ref. Category: High-Income group)*	7.4 (4.0-13.9)	3.8 (2.3-6.4)	4.7 (2.8-7.8)	4.2 (2.8-6.3)	2.6 (1.6-4.1)
Middle-Income Group *(ref. Category: High-Income group)*	3.2 (1.7-6.1)	2.3 (1.4-3.8)	2.7 (1.6-4.5)	2.2 (1.5-3.3)	2.1 (1.3-3.2)
Interaction of Low-Income Group and Weak TIPI Dimension	0.4 (0.2-0.8)	0.8[NS] (0.4-1.7)	0.7[NS] (0.3-1.3)	0.6[NS] (0.3-1.2)	1.6 [NS] (0.8-3.3)
Interaction of Middle-Income Group and Weak TIPI Dimension	0.5[NS] (0.2-1.1)	0.7[NS] (0.4-1.5)	0.6[NS] (0.3-1.2)	0.7[NS] (0.3-1.4)	0.9[NS] (0.4-1.8)

NS: Not Significant
ref. Category: Reference Category
PR: Prevalence Ratios
TIPI: The Ten-Item Personality Inventory
1: Model 1 comprised the interactions of personality traits (TIPI dimensions) with different income groups and the main effects of income and personality traits.

Table S4. Prevalence ratios from partially adjusted model[1] (Model 2) of SRDH

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
TIPI dimension *(ref. Category: Greater trait score)*	2.5 (1.3-4.9)	1.4[NS] (0.7-2.5)	1.9 (1.0-3.5)	2.7 (1.4-5.2)	1.3[NS] (0.7-2.5)
Low Income Group *(ref. Category: High-Income group)*	7.8 (4.1-14.7)	4.1 (2.5-6.8)	5.0 (3.0-8.4)	4.5 (2.9-6.7)	2.7 (1.7-4.4)
Middle Income Group *(ref. Category: High-Income group)*	3.3 (1.7-6.3)	2.3 (1.4-3.9)	2.8 (1.6-4.7)	2.3 (1.5-3.4)	2.1 (1.4-3.4)
Interaction of Low-Income Group and Weak TIPI Dimension	0.4 (0.2-0.8)	0.9[NS] (0.5-1.4)	0.6[NS] (0.3-1.3)	0.6[NS] (0.3-1.1)	1.6[NS] (0.8-3.1)
Interaction of Middle Income Group and Weak TIPI Dimension	0.5[NS] (0.3-1.4)	0.8[NS] (0.4-1.6)	0.6[NS] (0.3-1.1)	0.7[NS] (0.3-1.4)	0.9[NS] (0.4-1.8)

NS: Not Significant
ref. Category*:* Reference Category
PR: Prevalence Ratios
TIPI: The Ten-Item Personality Inventory
1: Model 2 adjusted for Socio-demographic characteristics (sex and age).

Table S5 Prevalence ratios from partially adjusted model[1] (Model 3) of SRDH

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
TIPI dimension *(ref. Category: Greater trait score)*	2.5 (1.3-4.9)	1.4[NS] (0.7-2.5)	1.9 (1.0-3.5)	2.7 (1.4-5.2)	1.3[NS] (0.7-2.5)
Low Income Group *(ref. Category: High-Income group)*	7.8 (4.1-14.7)	4.1 (2.5-6.8)	5.0 (3.0-8.4)	4.4 (2.9-6.7)	2.7 (1.7-4.3)
Middle Income Group *(ref. Category: High-Income group)*	3.3 (1.7-6.2)	2.3 (1.4-3.9)	2.7 (1.6-4.6)	2.3 (1.5-3.4)	2.1 (1.4-3.4)
Interaction of Low-Income Group and Weak TIPI Dimension	0.4 (0.2-0.8)	0.9[NS] (0.5-1.8)	0.7[NS] (0.3-1.3)	0.6[NS] (0.3-1.2)	1.6[NS] (0.8-3.2)
Interaction of Middle Income Group and Weak TIPI Dimension	0.5[NS] (0.2-1.1)	0.8[NS] (0.4-1.5)	0.6[NS] (0.3-1.2)	0.7[NS] (0.3-1.4)	0.9[NS] (0.4-1.8)

NS: Not Significant
ref. Category*:* Reference Category
PR: Prevalence Ratios
TIPI: The Ten-Item Personality Inventory
1: Model 3 adjusted for Socio-demographic characteristics (sex, age, main language spoken at home and birthplace).

Table S6 Prevalence ratios from crude model[1] (Model 1) of SRGH

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
TIPI dimension *(ref. Category: Greater trait score)*	2.1^{NS} (0.6-7.1)	2.0^{NS} (0.7-6.2)	0.9^{NS} (0.3-2.9)	7.0 (2.3-21.2)	6.0 (1.9-18.5)
Low Income Group *(ref. Category: High-Income group)*	8.3 (2.7-25.0)	8.8 (4.1-18.9)	8.7 (3.6-20.9)	16.9 (7.7-37.5)	15.5 (6.0-39.9)
Middle Income Group *(ref. Category: High-Income group)*	3.0^{NS} (0.9-9.8)	2.2^{NS} (0.9-5.0)	1.9^{NS} (0.7-4.8)	3.9 (1.7-9.1)	2.9 (1.0-8.1)
Interaction of Low-Income Group and Weak TIPI Dimension	1.0^{NS} (0.3-3.7)	0.9^{NS} (0.3-3.1)	1.1^{NS} (0.3-3.4)	0.2 (0.1-0.6)	0.4^{NS} (0.1-1.2)
Interaction of Middle Income Group and Weak TIPI Dimension	0.8^{NS} (0.2-3.2)	1.3^{NS} (0.4-4.4)	1.9^{NS} (0.6-6.7)	0.3^{NS} (0.1-1.2)	0.7^{NS} (0.2-2.6)

NS: Not Significant
ref. Category*:* Reference Category
PR: Prevalence Ratios
TIPI: The Ten-Item Personality Inventory
1: Model 1 comprised the interactions of personality traits (TIPI dimensions) with different income groups and the main effects of income and personality traits.

Table S7 Prevalence ratios from partially adjusted model[1] (Model 2) of SRGH

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
TIPI dimension *(ref. Category: Greater trait score)*	2.0[NS] (0.6-6.8)	2.0[NS] (0.6-6.0)	1.0[NS] (0.3-2.9)	7.7 (2.6-23.4)	6.6 (2.2-20.4)
Low Income Group *(ref. Category: High-Income group)*	6.8 (2.2-20.6)	7.8 (3.6-16.9)	7.4 (3.1-17.9)	14.4 (6.4-32.4)	12.6 (4.8-32.8)
Middle Income Group *(ref. Category: High-Income group)*	2.8[NS] (0.9-9.3)	2.1[NS] (0.9-4.8)	1.8[NS] (0.7-4.6)	3.8 (1.6-8.8)	2.8[NS] (1.0-7.8)
Interaction of Low-Income Group and Weak TIPI Dimension	1.1[NS] (0.3-4.0)	0.9[NS] (0.3-3.1)	1.1[NS] (0.3-3.6)	0.2 (0.1-0.6)	0.4[NS] (0.1-1.2)
Interaction of Middle Income Group and Weak TIPI Dimension	0.8[NS] (0.2-3.3)	1.3[NS] (0.4-4.5)	2.0[NS] (0.6-6.9)	0.3[NS] (0.1-1.1)	0.7[NS] (0.2-2.5)

NS: Not Significant
ref. Category*:* Reference Category
PR: Prevalence Ratios
TIPI: The Ten-Item Personality Inventory
1: Model 2 adjusted for Socio-demographic characteristics (sex and age).

Table S8 Prevalence ratios from partially adjusted model[1] (Model 3) of SRGH

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
TIPI dimension *(ref. Category: Greater trait score)*	2.0^{NS} (0.6-6.8)	2.0^{NS} (0.6-6.1)	0.9^{NS} (0.3-2.8)	7.6 (2.5-23.0)	6.5 (2.1-19.9)
Low Income Group *(ref. Category: High-Income group)*	6.7 (2.2-20.4)	7.7 (3.5-16.6)	7.2 (3.0-17.3)	14.0 (6.2-31.6)	12.2 (4.7-31.8)
Middle Income Group *(ref. Category: High-Income group)*	2.8^{NS} (0.9-9.4)	2.1^{NS} (0.9-4.8)	1.7 (0.7-4.5)	3.8 (1.6-8.8)	2.8 (1.0-7.7)
Interaction of Low-Income Group and Weak TIPI Dimension	1.1^{NS} (0.3-3.9)	0.9^{NS} (0.3-3.1)	1.2^{NS} (0.4-3.7)	0.2 (0.1-0.6)	0.4^{NS} (0.1-1.2)
Interaction of Middle Income Group and Weak TIPI Dimension	0.8^{NS} (0.2-3.2)	1.3 ^{NS} (0.4-4.5)	2.0^{NS} (0.6-7.0)	0.3^{NS} (0.1-1.1)	0.7^{NS} (0.2-2.5)

NS: Not Significant
ref. Category*:* Reference Category
PR: Prevalence Ratios
TIPI: The Ten-Item Personality Inventory
1: Model 3 adjusted for Socio-demographic characteristics (sex, age, main language spoken at home and birthplace).

8 Chapter 8: Can low-income people afford life satisfaction? The modifying effect of personality traits, a cross-sectional study

8.1 Highlights

- Findings showed the protective effect of high scores of positive personality traits (extraversion, conscientiousness, agreeableness, openness and emotional stability) in terms of life satisfaction (overall quality of life) at both low and high-income levels. Emotional stability and conscientiousness (to some extent) had the most noticeable effects.

- Low-income respondents with high scores for emotional stability and conscientiousness had a lower prevalence of low life satisfaction than high-income respondents with low scores for emotional stability and conscientiousness.

- High scores for openness, agreeableness and emotional stability modified the effect of low income on low life satisfaction, which points to the importance of these factors for low-income groups for their life satisfaction.

8.2 Statement of Authorship

Statement of Authorship

Title of Paper	Can low-income people afford life satisfaction? The modifying effect of personality traits, a cross-sectional study
Publication Status	☐ Published ☐ Accepted for Publication ☑ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
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Principal Author

Name of Principal Author (Candidate)	Mehrsa Zakershahrak		
Contribution to the Paper	Conceptualisation, design and implementation of research methodology Data analysis, and model design Manuscript writing – original draft preparation Editing and revisions Performing duties as corresponding author		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	22 August 2022

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate in include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Study 5: Can low-income people afford life satisfaction? The modifying effect of personality traits, a cross-sectional study

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Abstract

The aim was to investigate whether the "Big Five" personality traits (extraversion, agreeableness, openness, conscientiousness, and emotional stability) modify the association between household income and life satisfaction; and to evaluate the interaction and main effects of personality traits and income on life satisfaction. A cross-sectional study was conducted using data from the Dental Care and Oral Health Study (DCOHS, 2015-2016), including n=3,475 South Australian adults. Multivariable Poisson regression models (adjusted for demographics and health behaviours) assessed the main and interaction effects and effect modification of personality traits (measured using the Ten-Item Personality Inventory) on the association between income and life satisfaction (measured by the Satisfaction With Life Scale) using prevalence ratios (PRs). The Relative Excess Risk due to Interaction (RERI) was calculated to assess the direction of effect modification. Low scores for personality traits were associated with low life satisfaction. Among low-income respondents, low life satisfaction was less prevalent in those with high personality trait scores than those with low scores. The difference in the prevalence of low life satisfaction by personality traits was greater between low versus high income for openness (11.4% vs 7.7%), agreeableness (12.3% vs 9.4%) and emotional stability (26.1% vs 20.2%) categories. The combined effects of low income and low scores for these traits on life satisfaction also exceeded the sum of their individual effects, as shown by their positive RERIs. The association between low income and low life satisfaction was modified by high openness, agreeableness and emotional stability scores. Findings suggest that psychological interventions for improving life satisfaction would be most beneficial in low-income groups.

Keywords: income, subjective well-being, personality, life satisfaction, Big Five

Introduction

The relationship between income and well-being has been studied with a focus on life satisfaction (1). Many studies have shown that higher income is associated with higher life satisfaction (2, 3). Two complementary explanations are plausible for the positive relationship between income and life satisfaction. First, having a high income leads to a high living standard and a comfortable lifestyle (having positive experiences, avoiding negative experiences) (4, 5). High income facilitates consumption, which enhances satisfaction and decreases adverse experiences. Second, income affects life satisfaction through social comparisons (4). According to Wolbring et al. (6), comparing one's income with others around them predicts life satisfaction.

So, would it be accurate to conclude that income affects all individuals' life satisfaction in the same way? Or could individual differences (such as personality traits) change this association? Diener et al. (1) reported a weak association between income and life satisfaction. The effect of income on life satisfaction is diminished when basic needs are met (4, 6). Also, low-income individuals with strong personality traits cope better with stressful and adverse life circumstances (7). Therefore, low-income people could have high satisfaction in life with the help of high scores of personality traits. Personality traits are significantly associated with high life satisfaction (8). Those with high scores in extraversion (sociability and having the desire for social interaction), emotional stability (extreme opposite to neuroticism, being balanced and stable), agreeableness (tendency to be empathic and help others), conscientiousness (being self-disciplined and diligent), and openness (creativity, curiosity and being open to new experiences) are more likely to feel high life satisfaction (8).

While personality traits account for one-third of the variance in life satisfaction (9), individual differences in the association between income and life satisfaction are not fully explored. Thus, the present study aimed to evaluate the modifying effects of each personality trait on the association between income and life satisfaction among a population sample of South Australian adults. This study investigated the associations between personality traits and income (main effects and their interaction effects) with life satisfaction and whether higher scores on personality traits modify the effect of low household income on low life satisfaction. Effect modification occurs when the association (effect) between the primary exposure and the outcome changes depending on the second exposure stratum. The interaction effect refers to where two exposures have a combined effect on the outcome (10). Our hypotheses were: (i) low household income and low scores for personality traits (individually) would be associated with low life satisfaction; (ii) there would be interaction effects between household income and personality traits on the prevalence of life satisfaction; and (iii) among low-income individuals, the prevalence of low life satisfaction would be lower for those with high scores of personality traits than those with low personality trait scores.

Methods

This study used data from the Dental Care and Oral Health Study (DCOHS, 2015-2016), a cross-sectional population-based study. A sample of 12,245 South Australian adults (18 years or older) from the Electoral Roll was randomly selected to take part in the study. Participants were invited by mail, and participation in the DCOHS was entirely voluntary and confidential. Self-rated mailed questionnaires were sent to respondents and followed by up to three reminders. The University of Adelaide's Human Research Ethics Committee approved the DCOHS (H-288-2011) (11, 12).

Outcome variable

The overall quality of life was measured using the Satisfaction With Life Scale (SWLS) (based on Wilson and Cleary's model (13)). The SWLS is a valid and reliable scale (14) that comprises five items and measures an individual's overall satisfaction with their life on a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree) (14, 15). The scale score was calculated by summing the scores across the five items, resulting in a scale score between 5 and 25 (a score of 15 represents neutral SWLS). Higher scores represent higher life satisfaction (overall quality of life). Since the distribution of SWLS among respondents was not normal, scale scores were categorised (16) as those who were satisfied (higher life satisfaction, i.e., scores 16 or higher) and those who were dissatisfied with their lives (lower life satisfaction, i.e., scores 5-15). The reference category was those who had higher life satisfaction.

Exposure

The total household income before tax was assessed by asking the question, “Which category does your total household income (before tax) fall into?” with responses in 10 categories (from less than $20,000 to more than $180,000) in Australian Dollars. Income was categorised into two groups: low ($40,000 and less) and high income ($40,001 and more).

Effect modifier

The Big Five personality traits were assessed using the Ten-Item Personality Inventory (TIPI). Gosling (17) designed TIPI as a short and quick self-report test to assess the Big

Five personality traits. TIPI has acceptable psychometric validity and satisfactory test-retest reliability (17, 18). Each trait is measured using two items, a standard and a reverse-scored item. Therefore, TIPI has five standard items and five reverse-scored items. Items were scored on a 7-point Likert scale, where 1 = disagree strongly to 7 = agree strongly. The responses to the five reverse-scored items were recoded to match the standard items. Each trait's score was calculated by averaging the standard and the recoded reverse-scored items. Respondents with higher scores have a greater likelihood of showing that trait. Based on the responses, it was possible to determine where each respondent fit on the spectrum of each trait (ranging from 1 to 7). Therefore, each trait was categorised into high and low trait scores using a conceptual approach to divide the scale based on scores that yielded "agree" and higher scores (on average). Those scale scores that yielded "agree" and higher scores (scores 5-7) represented high personality trait scores (high TIPI). The categories comprised those who had high personality trait scores (high TIPI, scores 5-7) and those who had low personality trait scores (low TIPI, scores lower than 5).

Covariates

The other explanatory variables in the models were socio-demographic characteristics and health behaviours. Socio-demographic characteristics included sex, age groups (18-45, 46-60 and 61 years and more), the main language spoken at home (English/ other languages) and birthplace (Australia/ other countries). Health behaviours included dental insurance (insured/ uninsured), smoking status (current/ former/ non-smokers), daily toothbrushing (twice a day or more/ less than twice a day) and the last time for a dental visit (<12 months ago/ ≥12 months ago).

Statistical analysis

The analysis was limited to respondents who provided complete responses to all questions related to the exposure (income), effect modifier (personality traits) and outcome (SWLS). Also, respondents with missing responses in covariates were excluded from the Poisson regression. Thus, the final sample size with n=3475 was used in the analysis. The final sample was compared against participants with missing responses to account for possible response bias (the possibility of different answers of excluded cases and respondents included in the study). Also, the representativeness of the final study was evaluated by comparing it to census data. Finally, a descriptive analysis was conducted to describe the sample by life satisfaction (outcome). The data was weighted to the South Australian age and sex distribution based on population estimates.

The associations between income and low SWLS with each personality trait were evaluated in four multivariable models using generalised linear models with a log-Poisson link and robust errors. The first model assessed the unadjusted main effects of income categories and personality traits and their interaction effects with low SLWS. Then, conceptually relevant confounders (socio-demographic characteristics and health behaviours) were included sequentially in the analysis using a structured approach (19) to assess the adjusted main and interaction effects. Thus, model 1 analyses were adjusted in models 2 to 4 for different sets of covariates (model 2: sex and age - model 3: all socio-demographic characteristics; model 4: all covariates). These four models assessed the interaction effects and main effects of income and each personality trait, along with whether each personality trait modified the association between exposure (income) and low SWLS (outcome) (Figures S1-S3). The prevalence ratio (PR) was calculated as recommended for cross-sectional studies (20). Analyses were conducted using the IBM SPSS 28 software.

The effect measure modification (10) analysis was conducted because this study sought to assess whether each personality trait could modify the association between low income and low SWLS. Following Knol & VanderWeele's recommendations (21), the effect measure modification on the additive scale was assessed by calculating the relative excess risk due to interaction (RERI). The RERI was calculated using the generalized linear models with a log-Poisson link and robust errors to estimate PRs of low SWLS for different levels of income (exposure) and each personality trait (effect modifier) by entering a categorical variable as the exposure. This categorical variable was created by the combination of different levels of income (exposure) and personality traits (effect modifier) as follows:

a. high income and high personality trait score (reference group);

b. high income and low personality trait score;

c. low income and high personality trait score; and

d. low income and low personality trait score.

RERI for each personality trait was estimated using the following formula: PR(d)–PR(b)–PR(c) + PR(a), representing the risk that is in excess of what would be expected if the combination of personality traits and income was entirely additive. RERI was interpreted based on the direction of the effect-measure modification rather than its size, as suggested by Knol & VanderWeele (21). A RERI>0 (i.e., a positive effect measure modification) shows that the combined effects of the low income and low scores of personality traits are greater than the sum of their independent effects on low life satisfaction. A RERI equal to 0 represents no evidence for effect measure modification, and RERI<0 (negative RERI) shows a negative direction for effect measure modification. STATA 17 was used for calculating RERI.

Separate PRs were also estimated for the effects of low income on low SWLS for each personality trait stratum. The effect modification provided insights into the associations between different levels of exposure (income) with the outcome variable (SWLS) according to each level of the effect modifier (personality traits). Thus, we were able to assess how the association between low income and low life satisfaction (quality of life) changed when respondents had high scores for personality traits.

Results

There were 4,494 responses (44.8% response rate). A total of 3,475 responses were included in the final analysis (after excluding n=1,019 participants with missing responses). More than half of the study sample were female (55.8%) and non-smokers (54.4%) (Table 1). Over a quarter of the study sample had low life satisfaction (26.2%), and were from the low-income category (27.9%). The prevalence of low life satisfaction was highest among current smokers (43.2%), low-income respondents (38.5%) and those without dental insurance (34.8%).

Most of the study sample had high personality trait scores across four of the five traits. The exception was that only 35.9% of respondents had high extraversion scores, as presented in Table 2. The prevalence of low life satisfaction was highest among respondents with low scores of conscientiousness (42.5%) and emotional stability (39.3%).

The final study sample was compared to those with missing answers to evaluate the response bias (Table S1). Overall, excluded participants were similar to the final study respondents. While both samples differed in health behaviours and age groups, the differences were not statistically significant (except for dental insurance, tooth brushing and young and old age groups).

The final sample was compared against the South Australian population data using 2016 census data to assess its representativeness (Table S2). Both populations were broadly similar, except for a higher proportion of Australian-born and high-income individuals and a lower proportion of older participants in the final sample compared to census data.

Low household income was associated with low life satisfaction across all models, with PRs ranging from 1.95 to 2.70, showing a high prevalence of low life satisfaction among low-income respondents (Table 3, S3-S5). All low personality traits were associated with low life satisfaction across all models. In particular, a higher prevalence of low life satisfaction was observed among those with low scores for conscientiousness (across all models, PRs ranging from 1.83 to 2.03) and emotional stability (across all models, PRs ranging from 2.68 to 2.77). The low PRs of the interaction effects (the measure of interaction on a multiplicative scale) between the low-income group and low emotional stability score (models 2-4, PRs ranging from 0.72 to 0.75), low extraversion and lower-income (model 2-4, PRs ranging from 0.73 to 0.75) and low conscientiousness and low income (all models, PRs ranging from 0.66 to 0.71) indicated a significantly greater effect of these traits at the high-income group (Figure S4). The low PRs reflect a lower prevalence of low life satisfaction among high-income respondents with high emotional stability, extraversion and conscientiousness scores (indicating a relatively greater effect for the advantage of high emotional stability, extraversion and conscientiousness scores in the high-income group). There were no statistically significant interactions between income and openness and income and agreeableness across all models (no significant measure of interaction on a multiplicative scale).

Table 4 presents the analysis of the effect measure modification of each personality trait with the association between low household income and low life satisfaction. Among those with high personality trait scores, the relative effect of income on the prevalence of low life satisfaction was higher (PRs ranging from 1.87 for emotional stability to 2.20 for extraversion) than those with low trait scores (PRs ranging from 1.43 for conscientiousness to 1.85 for agreeableness). Among all respondents, the highest prevalence of low life satisfaction was for those from the low-income group with low personality traits scores (PRs ranging from 2.33 to 3.54). The negative measures of RERI for extraversion and conscientiousness indicate negative interaction on an additive scale, showing that the combined effect of low income and low personality trait score (for each of these traits, respectively) was less than the sum of the effects of low income and low personality traits, individually. The positive measures of RERI observed for openness (RERI=0.15, 95% CI [-0.20 – 0.52]) and emotional stability (RERI=0.19, 95% CI [-0.30 – 0.69]), reflected that the combined effects of low income and low scores of each of these traits on low life satisfaction were higher than the sum of their individual effects, in relation to the reference category of high income and high personality trait scores. Low-income respondents with high emotional stability scores reported a comparatively lower prevalence of low life satisfaction (25.1%, PR=1.92) than high-income respondents with low emotional stability scores who reported a higher prevalence of low life satisfaction (33.4%, PR=2.42).

The difference in the prevalence of low life satisfaction between low and high extraversion scores for low-income respondents was 7.6%, while for high-income respondents was 9.6%, inferring a greater effect of high extraversion at high-income level versus low-income level (confirmed by negative RERI) as presented in Table 4. There was a greater difference between low and high openness scores for individuals (11.4%)

at the low-income level than at the high-income (7.7%). Among low-income respondents, those with high agreeableness scores (34.6%) had a lower prevalence of low life satisfaction than those with low agreeableness scores (46.9%), with a greater difference at the low-income level between low and high agreeableness scores (12.3%), than at high income (9.4%). The difference in the prevalence of low life satisfaction between low and high conscientiousness scores was lower for low-income (16.9%) versus high-income respondents (19.6%), suggesting a greater effect of high conscientiousness at the high-income level versus low-income level (confirmed by negative RERI). The greater difference in the prevalence of low life satisfaction between low and high emotional stability scores at the low-income level (26.1%) versus the high-income level (20.2%) suggested a greater effect of high emotional stability at the low-income level than at the high-income level. Also, low-income respondents with high conscientiousness scores (34.7%), and high emotional stability scores (25.1%) had a lower prevalence of low life satisfaction than high-income respondents with low conscientiousness (37.7%) and emotional stability scores (33.4%).

Discussion

This study assessed the effect modification of high personality traits in the association between low income and low life satisfaction, along with the interaction and main effects of personality traits and income on low life satisfaction. All models showed strong associations between low scores of "Big Five" personality traits (extraversion, openness, agreeableness, conscientiousness, and emotional stability) and low life satisfaction. Also, low income was associated with a high prevalence of low life satisfaction (regardless of control for covariates). The interaction effects (the measure of interaction on a multiplicative scale) between low income and low scores for extraversion (adjusted for covariates), conscientiousness (regardless of control for covariates) and emotional stability (adjusted for covariates) with low life satisfaction were observed. High scores of openness and agreeableness positively modified the effect of low income on low life satisfaction, with no significant measure of interaction on a multiplicative scale across all models. Extraversion and conscientiousness negatively modified the effect of low income on low life satisfaction, which along with the low PRs of their interaction effects with income, point to a greater effect of high scores of these traits for high-income respondents. The modifying effects of high emotional stability scores in the association between income and low life satisfaction were observed, suggesting greater opportunities for improving life satisfaction (quality of life) through interventions targeting emotional stability for low-income groups.

Knol and VanderWeele recommend presenting effect modification and interaction in multiplicative and additive scales in order to convey their size and significance (21). The interaction on an additive scale implies that the combined effect of two exposure variables is greater or smaller than the sum of their individual effects (22). The interaction on a multiplicative scale shows that the combined effect of both exposure variables is not equal to (greater/smaller than) the product (multiplication interaction; i.e., low income by low personality trait scores) of the individual effects (22). Specifically, the multiplicative interaction compares differences in relative effect measures of association across strata (e.g., the PRs in this study). The additive interaction compares different measures of association across strata (e.g., differences between PRs). The product term of both exposures can be obtained from generalised linear models (e.g., Poisson regression), whereas the additive interaction should be calculated using RERI (if the exposures are binary) (23). The additive interaction points to which group of the population would most likely benefit from the intervention targeting the effect modifier (23). The current study investigated interactions on both additive and multiplicative scales.

The association between low income and low life satisfaction is supported by previous findings (2, 3). Also, recent studies (3, 24) have shown that personality traits moderated the effects of income changes on life satisfaction, which is in line with the current study's findings. Individuals with high openness scores are better able to adapt to life situations, allowing them to manage their life satisfaction at low-income levels as stressful situations (25, 26). Also, those with high agreeableness scores are more likely to employ adaptive coping strategies when facing a challenging life situation (26). If their coping strategies are successful, their life satisfaction will be more stable (25).

The current study showed that emotional stability was a protective factor for life satisfaction among low-income individuals. RERI suggested the risk of low life satisfaction due to low income and low emotional stability (high neuroticism) score are beyond what would be expected if the combination of risks due to low income and low emotional stability score (high neuroticism) was entirely additive. Findings suggested the importance of emotional stability for improving life satisfaction among low-income groups. These findings were congruent with previous research stating emotional stability is a significant predictor of life satisfaction (8). Emotionally stable individuals experience low sensitivity to failures and negative experiences (as opposed to high neuroticism) (3). If having low-income results in increased exposure to negative experiences, and emotionally stable individuals are less likely to be affected by these experiences, then a multiplicative effect is expected (as presented in effect modification findings) for emotionally stable individuals at the low-income level regarding their life satisfaction.

Having higher conscientiousness scores at the low-income level was better (in terms of lower prevalence of poor life satisfaction) or equivalent (in terms of comparable PRs) to having lower conscientiousness scores at the high-income level. Conscientiousness has been shown as a possible beneficial trait for low SES people's health (which is linked to life satisfaction) (27). However, extraversion and conscientiousness did not modify the effect of low income on life satisfaction. These two traits could act as double-edged swords and reduce life satisfaction depending on the situation. High conscientiousness individuals experience high distress from failures and unpleasant life situations (such as financial loss and unemployment) (28). Also, they could be more satisfied with an increase in income to the extent that having more money (collecting wealth) is a potential goal for them (28, 29). Therefore, having low income or being unemployed (which could result in low income) could be in the way to reaching that goal and result in high stress and reduced satisfaction and well-being (29). Soto and Luhmann (3) reported similar results that extraversion did not moderate the effects of income on life satisfaction. Also, Syrén et al. (24) found that extraversion negatively moderated the association between monthly gross income and emotional and mental well-being. Those high in extraversion are more sensitive to their income ranks (30). Consequently, where they are (their position) in the income distribution of the reference group has a significant effect on their life satisfaction (30). As a result, low income could negatively affect their satisfaction with life. Also, highly extraverted individuals react strongly to positive experiences (31). Given that low income could lead to less frequent positive experiences and the importance of income ranking for extraverted individuals, then it is logical to have a strong association between income and life satisfaction for high extraversion individuals at the high-income level (i.e., a greater effect of high extraversion at high-income level). In other words, a multiplicative effect of low extraversion and low income on their life satisfaction is plausible.

Notwithstanding the strengths of the current study, including the large and state-representative sample, four multivariable regression models to assess consistent associations and similar patterns, estimates of interactions on both additive and multiplicative scales, and the use of validated and reliable scales, there were some limitations. Foremost among these is the DCOHS response rate of 44.8%, which is congruent with other human research surveys' response rates (below 50%) over the last thirty years (32). This sample was recruited from the Electoral Roll in Australia, which is a comprehensive sample frame. In line with previous studies (11, 12), DCOHS was broadly representative of the age and sex distributions of the South Australian adult population compared to the general population. In addition, the final sample used for analysis represented the characteristics of South Australian adults, which differed slightly in the country of birth, age distribution, and income groups. It should be noted that the way age and income were categorised in census data differed from the study sample. Also, the final study sample was comparable to participants excluded from the analysis due to missing responses, so there was little evidence of response bias.

The present findings underline the potential role of psychological factors in the possibility of improving life satisfaction (33) (which is linked to health (13)) for low-income groups. Psychological interventions using mindfulness programs (33) and community-level positive psychology (34) have significantly enhanced life satisfaction. The findings assist health policies and future investigations and multidimensional approaches to address well-being for socioeconomically disadvantaged groups. The current study's findings should be interpreted with bearing in mind that life satisfaction is not the only component of subjective well-being (SWB). The importance of the mental component of quality of life and positive and negative affect as other aspects of SWB (33) should not be overlooked.

In conclusion, the current study showed the associations between the "Big Five" personality traits and income with life satisfaction. All personality traits were protective at the low and high-income levels. In other words, those with high personality trait scores had a lower prevalence of low life satisfaction at both income levels. The most obvious effects were observed for emotional stability and, to some extent, conscientiousness, where there was a clear contrast between low conscientiousness scores at low income and high conscientiousness scores at high income. The effects of high conscientiousness at low income were roughly equivalent to low conscientiousness at high income. Having high scores for emotional stability, openness, and agreeableness were beneficial psychological factors among low-income individuals for their life satisfaction; these findings point to the possibility of improving life satisfaction (quality of life) through interventions targeting these traits for low-income groups. The question “Do personality traits modify the effect of other domains of life (e.g., education, work, relationships, religious belief, and health) on life satisfaction and other aspects of well-being?” needs to be addressed in future research.

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Table 1. Description of the final study sample

	Distributions * (n=3475)	Low SWLS (low life satisfaction)	
	N (%)	N (%)	95% CI
(n=3475)		**909 (26.2)**	**24.5-27.9**
Health behaviour			
Last Dental Visit			
Within The Past Year	2175 (62.6)	495 (22.8)	20.8-24.9
One Year Ago And More	1300 (37.4)	414 (31.8)	28.9-35.1
Dental Insurance			
With Insurance	2411 (69.4)	539 (22.4)	20.5-24.3
Without Insurance	1064 (30.6)	370 (34.8)	31.3-38.5
Smoking Status			
Non-Smoker	1890 (54.4)	426 (22.5)	20.4-24.8
Former Smoker	1189 (34.2)	312 (26.2)	23.4-29.3
Current Smoker	396 (11.4)	171 (43.2)	37.0-50.2
Toothbrushing Frequency			
Twice Daily Or More	1920 (55.3)	426 (22.2)	20.1-24.4
Less Than Twice Daily	1555 (44.7)	483 (31.1)	28.4-34.0
Socio-demographic characteristics			
Country Of Birth			
Australia	2751 (79.2)	706 (25.7)	23.8-27.6
Other Countries	724 (20.8)	203 (28.0)	24.3-32.2
Main Language Spoken At Home			
English Speakers	3331 (95.9)	860 (25.8)	24.1-27.6
Other Languages	144 (4.1)	49 (34.0)	25.2-45.0
Sex			
Male	1536 (44.2)	419 (27.3)	24.7-30.0
Female	1939 (55.8)	490 (25.3)	23.1-27.6
Age Categories (Mean= 52.5)			
18-45 years	1130 (32.5)	299 (26.5)	23.5-29.6
46-60 years	1131 (32.5)	340 (30.1)	27.0-33.4
61 years and older	1214 (35.0)	270 (22.2)	19.7-25.1
Income Categories			
High (>$40,000)	2504 (72.1)	535 (21.4)	19.6-23.3
Low (≤$40,000)	971 (27.9)	374 (38.5)	34.7-42.6

* The final sample size used for the analysis, including all variables with non-missing data

SWLS: Satisfaction With Life Scale

Table 2. Descriptive characteristics of the final study sample by the effect modifier

	Distributions * (n=3475)	Low SWLS (low life satisfaction)	
	N (%)	N (%)	95% CI
(n=3475)		**909 (26.2)**	**24.5-27.9**
Personality traits			
Extraversion			
Higher	1248 (35.9)	242 (19.4)	17.0-22.0
Lower	2227 (64.1)	667 (30.0)	27.7-32.3
Openness			
Higher	2029 (58.4)	450 (22.2)	20.2-24.3
Lower	1446 (41.6)	459 (31.7)	28.9-34.8
Agreeableness			
Higher	2250 (64.7)	514 (22.8)	20.9-24.9
Lower	1225 (35.3)	395 (32.2)	29.1-35.6
Conscientiousness			
Higher	2832 (81.5)	636 (22.5)	20.7-24.3
Lower	643 (18.5)	273 (42.5)	37.6-47.8
Emotional Stability			
Higher	1966 (56.6)	316 (16.1)	14.3-17.9
Lower	1509 (43.4)	593 (39.3)	36.2-42.6

*** The final sample size used for the analysis, including all variables with non-missing data**

SWLS: Satisfaction With Life Scale

Table 3 Interaction between personality traits and income with low life satisfaction in the fully adjusted model† (Model 4)

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
Personality Trait *(Ref. Category: High personality trait score category)*	1.61 (1.33-1.95)	1.44 (1.22-1.70)	1.42 (1.20-1.68)	1.83 (1.54-2.18)	2.68 (2.25-3.18)
Low-Income Group *(Ref. Category: High-Income group)*	2.34 (2.5-8.1)	2.01 (1.67-2.43)	2.06 (1.73-2.45)	2.17 (1.84-2.56)	2.15 (1.69-2.74)
Interaction‡ Between Low-Income Group And Low Personality Trait Score	0.75 (0.57-0.98)	0.90 (0.71-1.13) *	0.90 (0.71-1.13) *	0.66 (0.52-0.83)	0.72 (0.55-0.94)

PR: Prevalence Ratios
Ref. Category*:* Reference Category
* Not Significant

† Model 4 adjusted for Socio-demographic characteristics (sex, age, main language spoken at home and birthplace) and Health behaviour (daily tooth brushing, smoking status, dental insurance and last dental visit).

‡ Measure of interaction on multiplicative scale (95% CI).

Table 4 Effect modification of personality trait in the association between income and low life satisfaction from the fully adjusted model (model 4)

	Low Income		High Income		PR (95%CI) for low income within strata of personality trait
	N (%) low/high Life satisfaction	PR (95%CI)	N (%) low/high Life satisfaction	PR (95%CI)	
Extraversion					
Low personality trait score	282/411 (40.7/59.3)	2.53 (2.10-3.04)	385/1149 (25.1/74.9)	1.59 (1.34-1.89)	1.79 (1.54-2.08)
High personality trait score	92/186 (33.1/66.9)	2.13 (1.69-2.68)	150/820 (15.5/84.5)	1.00 (Ref.)	2.20 (1.64-2.95)
Measure of interaction on additive scale: RERI (95% CI) = -0.19 (-0.66, 0.27)					
Openness					
Low personality trait score	199/246 (44.7/55.3)	2.37 (2.02-2.78)	260/741 (26.0/74.0)	1.42 (1.22-1.64)	1.78 (1.49-2.13)
High personality trait score	175/351 (33.3/66.7)	1.79 (1.51-2.13)	275/1228 (18.3/81.7)	1.00 (Ref.)	2.10 (1.72-2.57)
Measure of interaction on additive scale: RERI (95% CI) = 0.15 (-0.20, 0.52)					
Agreeableness					
Low personality trait score	144/163 (46.9/53.1)	2.33 (1.97-2.76)	251/667 (27.3/72.7)	1.43 (1.23-1.66)	1.85 (1.52-2.25)
High personality trait score	230/434 (34.6/65.4)	1.88 (1.61-2.21)	284/1302 (17.9/82.1)	1.00 (Ref.)	2.07 (1.72-2.49)
Measure of interaction on additive scale: RERI (95% CI) = 0.01 (-0.36, 0.39)					
Conscientiousness					
Low personality trait score	114/107 (51.6/48.4)	2.47 (2.09-2.93)	159/263 (37.7/62.3)	1.88 (1.61-2.19)	1.43 (1.15-1.79)
High personality trait score	260/490 (34.7/65.3)	1.90 (1.64-2.20)	376/1706 (18.1/81.9)	1.00 (Ref.)	2.15 (1.82-2.56)
Measure of interaction on additive scale: RERI (95% CI) = -0.30 (-0.74, 0.13)					
Emotional stability					
Low personality trait score	256/244 (51.2/48.8)	3.54 (2.99-4.19)	337/672 (33.4/66.6)	2.42 (2.07-2.83)	1.64 (1.42-1.89)
High personality trait score	118/353 (25.1/74.9)	1.92 (1.55-2.37)	198/1297 (13.2/86.8)	1.00 (Ref.)	1.87 (1.41-2.49)
Measure of interaction on additive scale: RERI (95% CI) = 0.19 (-0.30, 0.69)					

Prevalence ratios (PRs) from Model 4 adjusted for: Socio-demographic characteristics (sex, age, main language spoken at home and birthplace) and Health behaviour (daily tooth brushing, smoking status, dental insurance and last dental visit).

Table S1. Comparison of the study respondents, DCOHS, and excluded respondents

	Final study sample (n=3475) *	DCOHS (n=4494)	Excluded respondents † (n= 1019)
	% (95% CI)	% (95% CI)	% (95% CI)
Health behaviour variables			
Last Dental Visit			
Less Than A Year Ago	62.6 (60.0-65.3)	61.1 (58.8-63.4)	55.8 (51.3-60.7)
A Year Ago And More	37.4 (35.4-39.5)	38.9 (37.1-40.8)	44.2 (40.1-48.5)
Dental insurance			
Insured	69.4 (66.6-72.2)	67.2 (64.8-69.7)	59.3 (54.5-64.4)
Uninsured	30.6 (28.8-32.5)	32.8 (31.1-34.5)	40.7 (36.7-45.0)
Smoking Status			
Non-Smoker	54.4 (52.0-56.9)	54.3 (52.2-56.5)	54.1 (49.5-58.9)
Former Smoker	34.2 (32.3-36.2)	33.9 (32.2-35.7)	32.8 (29.2-36.6)
Current Smoker	11.4 (10.3-12.6)	11.8 (10.8-12.8)	13.2 (11.0-15.7)
Tooth Brushing			
Twice A Day Or More	55.3 (52.8-57.8)	53.8 (51.6 -56.0)	48.0 (43.5-52.8)
Less Than Twice A Day	44.7 (42.6-47.0)	46.2 (44.2-48.3)	52.0 (47.4-57.0)
Demographics			
Place of Birth			
Australia	79.2 (76.2-82.2)	78.7 (76.1-81.4)	77.1 (71.5-83.0)
Other	20.8 (19.3-22.4)	21.3 (19.9-22.7)	22.9 (19.9-26.2)
Main Language Spoken At Home			
English	95.9 (92.6-99.2)	95.5 (92.6-98.4)	94.0 (92.3-95.4)
Other	4.1 (3.5-4.9)	4.5 (3.9-5.2)	6.0 (4.5-7.9)
Sex			
Male	44.2 (42.0-46.5)	44.0 (42.0-46.0)	43.2 (39.2-47.4)
Female	55.8 (53.3-58.3)	56.0 (53.9-58.3)	56.8 (52.3-61.6)
Age Groups			
18-45 years	32.5 (30.6-34.5)	30.0 (28.4-31.6)	21.2 (18.5-24.2)
46-60 years	32.5 (30.7-34.5)	31.5 (29.9-33.1)	27.8 (24.6-31.2)
≥61 years	35.0 (33.0-37.0)	38.5 (36.8-40.4)	51.0 (46.7-55.6)

DCOHS: The Dental Care and Oral Health Study
* The final sample size used for the analysis, including all variables with non-missing data
† The excluded respondents were excluded due to missing responses (missing data).

Table S2. The characteristics of the study respondents versus the general population

	Final study sample [1]	Final study sample (weighted) [1]	2016 South Australia Census data
Demographics (%)			
Place of Birth			
Australia	79.2	81.9	71.1
Other	20.8	18.1	28.9
Sex			
Male	44.2	49.6	49.3
Female	55.8	50.4	50.7
Age Groups			
18-45 years	32.5	49.7	41.7*
46-60 years	32.5	25.8	26.5**
≥61 years	35.0	24.5	31.8***
Income Groups (%)			
≤$40,000	27.9	25.7	33.2[a]
>$40,000	72.1	74.3	66.7[b]

1 The final sample size used for the analysis, including all variables with non-missing data

** 20-44 years*
*** 45-59 years*
**** ≥60 years*

a ≤ $41,599 (<$799/week)
b ≥$41,600 (≥$999/week)

Table S3 Interaction between personality traits and income with low life satisfaction in Model 3†

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
Personality Trait *(Ref. Category: High personality trait score category)*	1.64 (1.35-1.99)	1.47 (1.25-1.74)	1.44 (1.22-1.71)	1.97 (1.65-2.35)	2.76 (2.32-3.28)
Low-Income Group *(Ref. Category: High-Income group)*	2.69 (2.10-3.46)	2.30 (1.92-2.75)	2.34(1.98-2.77)	2.40 (2.06-2.80)	2.32 (1.83-2.94)
Interaction‡ Between Low-Income Group And Low Personality Trait Score	0.73 (0.55-0.97)	0.90 (0.71-1.14) *	0.90 (0.71-1.13) *	0.68 (0.53-0.87)	0.75 (0.58-0.98)

PR: Prevalence Ratios
Ref. Category*:* Reference Category
* Not Significant

† Model 3 adjusted for Socio-demographic characteristics (sex, age, main language spoken at home and birthplace).

‡ Measure of interaction on multiplicative scale (95% CI).

Table S4 Interaction between personality traits and income with low life satisfaction in Model 2†

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
Personality Trait *(Ref. Category: High personality trait score category)*	1.64 (1.35-1.99)	1.47 (1.25-1.74)	1.45 (1.22-1.72)	1.98 (1.67-2.36)	2.77 (2.33-3.30)
Low-Income Group *(Ref. Category: High-Income group)*	2.70 (2.11-3.46)	2.31 (1.93-2.77)	2.36 (2.00-2.80)	2.42 (2.07-2.82)	2.34 (1.85-2.97)
Interaction‡ Between Low-Income Group And Low Personality Trait Score	0.74 (0.56-0.97)	0.90 (0.71-1.14) *	0.89 (0.70-1.12) *	0.67 (0.53-0.85)	0.75 (0.57-0.97)

PR: Prevalence Ratios
Ref. Category: Reference Category
* Not Significant

† Model 2 adjusted for sex and age.

‡ Measure of interaction on multiplicative scale (95% CI).

Table S5 Interaction between personality traits and income with low life satisfaction in Model 1†

	Extraversion	Openness	Agreeableness	Conscientiousness	Emotional Stability
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
Personality Trait *(Ref. Category: High personality trait score category)*	1.66 (1.37-2.01)	1.47 (1.24-1.73)	1.50 (1.27-1.78)	2.03 (1.71-2.42)	2.74 (2.30-3.26)
Low-Income Group *(Ref. Category: High-Income group)*	2.24 (1.75-2.87)	1.98 (1.66-2.37)	2.00 (1.70-2.36)	2.06 (1.77-2.39)	1.95 (1.56-2.46)
Interaction‡ Between Low-Income Group And Low Personality Trait Score	0.77 (0.58-1.02) *	0.89 (0.70-1.13) *	0.94 (0.74-1.19) *	0.71 (0.55-0.90)	0.82 (0.63-1.06) *

PR: Prevalence Ratios
Ref. Category*:* Reference Category
* Not Significant

† crude model; not adjusted for covariates.

‡ Measure of interaction on multiplicative scale (95% CI).

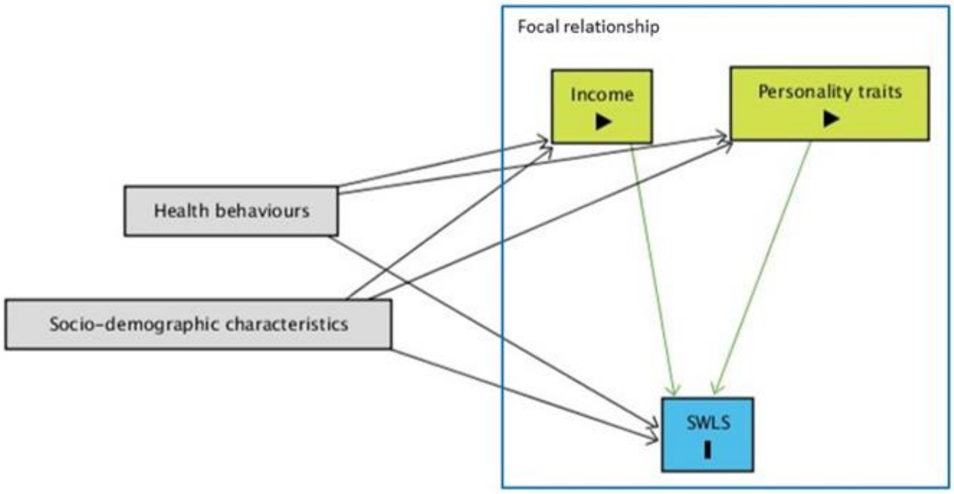

Fig. S1 Directed Acyclic Diagram (DAG) with the focal relationships between personality traits and income as the main exposures and Satisfaction With Life Scale (SWLS) as the outcome

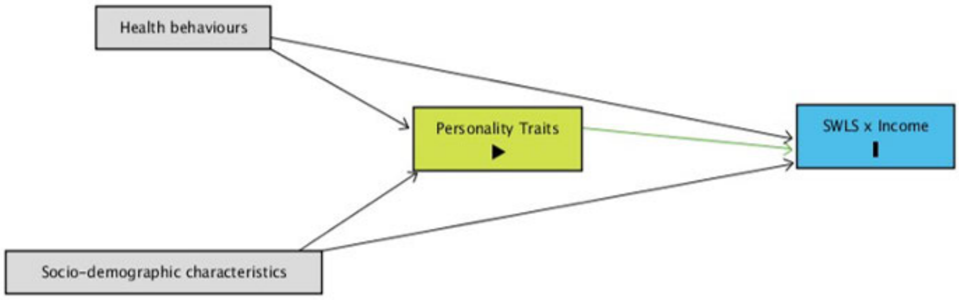

Fig. S2 Direct Acyclic Diagram (DAG) with the interaction effect between personality traits and income as the main exposures

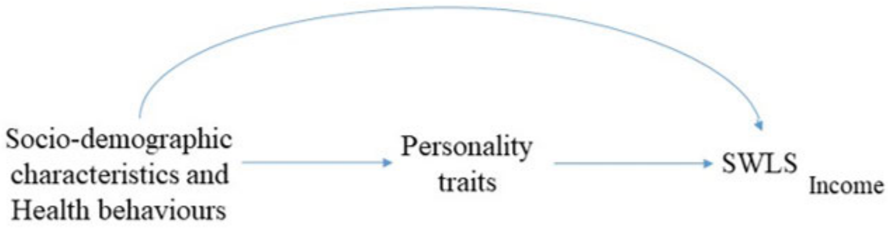

Fig. S3 Interaction Directed Acyclic Diagram (IDAG) of the interaction effect between the personality traits and income as the main exposures

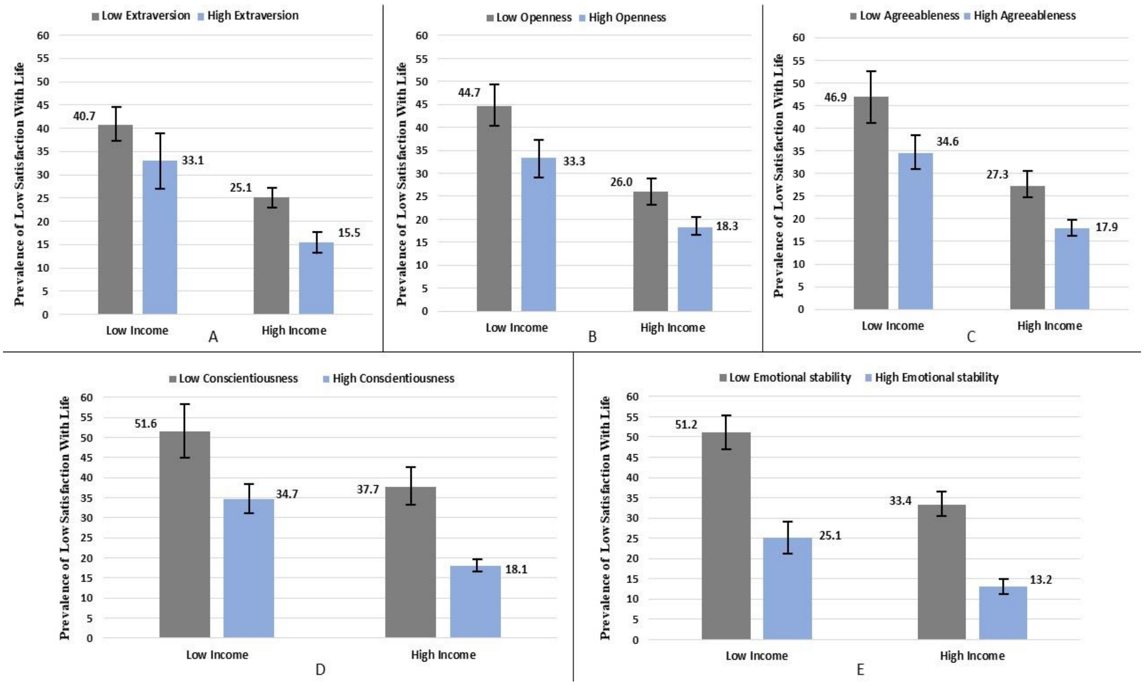

Figure S4: Low Satisfaction With Life by personality trait dimensions and income groups (A: Low Satisfaction With Life by Extraversion; B: Low Satisfaction With Life by Openness; C: Low Satisfaction With Life by Agreeableness; D: Low Satisfaction With Life by Conscientiousness; E: Low Satisfaction With Life by Emotional Stability)

9 General discussion and conclusion

This thesis aimed to answer the general question of "do psychosocial factors such as SOC and personality traits help low-income individuals to mitigate the adverse effect of low income on their health and quality of life and maintain good health and quality of life?". Therefore, this thesis investigated: (i) the main effects of psychosocial factors and household income levels, (ii) their interaction effects, and (iii) the modifying effect of psychosocial factors on the association between household income levels with health and quality of life outcome measures following the Wilson and Cleary's (1995) model of health-related quality of life (HRQoL) (Figure 9.1). The five studies presented in this thesis followed the order of the underlying health concepts in Wilson and Cleary's model (i.e., used patient outcome measures in the same order). The outcomes used in the studies were a subset representing the higher-end outcomes of Wilson and Cleary's model (clinical measures and symptoms were not included in the analyses):

- Study 1 (using SOC) and study 2 (using personality traits) investigated the mentioned effects on oral and general health functional status (measured using the OHIP-14 and EQ-5D, respectively).

- Study 3 (using SOC) and study 4 (using personality traits) investigated the mentioned effects on general health perceptions (measured using SRDH and SRGH).

- Study 5 (using personality traits) investigated the mentioned effects on the overall quality of life (measured using SWLS).

In the final study, I focussed on the effect of personality traits on the overall quality of life since personality traits are considered as more fundamental concepts than SOC (Feldt et al., 2007). However, the models which analysed the effects of SOC on the overall quality of life (measured using SWLS) are included for completeness (See Appendix 1. Models for the effects of sense of coherence (SOC) on the overall quality of life (measured using SWLS)).

The first step was to evaluate the income gradient (as the main effect of different income levels) in self-reported health and quality of life among a representative South Australian population sample. Also, the presented studies assessed whether having high psychosocial factors (represented as SOC and personality traits) was associated with lower poor self-rated health and quality of life among low-income individuals. Then, the associations between psychosocial factors and self-reported health and quality of life were assessed. Furthermore, the interaction effects (joint effects) between psychosocial factors and income on self-reported health and quality of life were investigated. Next, the modifying effect of psychosocial factors on the associations between income and self-reported health and quality of life was investigated. Effect measure modification provided insight into which income groups could benefit the most (achieving potential gains the most) by having strong SOC and high scores for personality traits in terms of health and quality of life (in terms of absolute differences in the prevalence of poor SRDH, SRGH and SWLS (life satisfaction), and average levels of poor OHIP-14 (OHRQoL) and EQ-5D-3L (HRQoL) at different income levels).

9.1 Findings Overview

A summary of findings across all five studies included in the thesis is presented in Table 9.1. The findings of these studies showed that health and quality of life are influenced by income gradients among South Australian adults. Overall, the findings highlight the importance of psychosocial factors as protective psychological resources for the health and wellbeing of low-income individuals. The protective psychosocial factors (SOC and personality traits) were positively associated with OHRQoL, HRQoL, SRDH, SRGH and life satisfaction at all household income levels. In other words, those with high scores for the "Big Five" personality traits and strong SOC (i.e., high coherence) generally had better OHRQoL and HRQoL, lower prevalence of poor SRDH and SRGH, and lower prevalence of life satisfaction at all income levels than those with low scores for personality traits and weak SOC (i.e., low coherence). These findings suggest a protective effect of SOC and personality traits on health and quality of life outcome measures following Wilson and Cleary's model (functional status, general health perception, overall quality of life), especially for low-income groups, among a representative sample of the South Australian adults. Also, the findings emphasised the modifying effect of high scores for certain personality traits and strong SOC on the association between income and poor health and quality of life outcome measures. The following paragraphs provide further details on these findings.

In the first step, the associations between the main effect of income and the outcome variables at the levels of functional status, general health perceptions and overall quality of life remained even after adjusting for health behaviour variables (i.e., regardless of control for covariates). These findings showed that the associations between low income and poor health and quality of life could not be explained solely by health behaviours as outlined in Chapter 1 (See 1.2.1). Also, the associations (as main effects) were observed between protective psychosocial factors and the outcome variables at the levels of functional status, general health perceptions and overall quality, regardless of control for covariates: weak SOC (except for SRDH); low scores for extraversion (except for functional status and SRGH), openness (except for functional status and general health perceptions), agreeableness (except for functional status and SRGH), conscientiousness (except for OHRQoL), and emotional stability (except for SRDH) were associated with poor health and quality of life. These findings suggest that the association between protective psychosocial factors and health and quality of life was confirmed regardless of sociodemographic characteristics and health behaviours.

Next, there were interaction effects between psychosocial factors and income on health and quality of life outcome measures:

1- The interaction effect between SOC and income on functional health (OHRQoL and HRQoL) and emotional stability and income on HRQoL were consistent, regardless of control for covariates. However, there was no interaction effect between income and emotional stability on OHRQoL after adjusting for health behaviour variables (in the fully adjusted model), reflecting the impact of controlling for these covariates. This finding indicates that the joint effect of income and emotional stability on OHRQoL is partially explained by health behaviours (Zakershahrak & Brennan, 2022).

2- Consistent interaction effects between low extraversion scores and income on SRDH and low conscientiousness scores and income on SRGH (general health perception) were observed regardless of control for covariates.

3- Conscientiousness and income had consistent interactions on the overall quality of life (life satisfaction) regardless of control for covariates. The interaction effects between extraversion and income and emotional stability and income were observed in models adjusted for sociodemographic characteristics and health behaviour variables.

All studies in this thesis interpreted interaction terms as differences in prevalence or mean scores of outcome measures at each stratum of exposure (income levels) as to whether these differences were greater or less. There was no inconsistency in the direction of the effects and interactions across all studies and between oral and general health outcome measures. The interaction effect between protective psychosocial factors and income revealed a greater joint effect between high income and strong SOC, and high scores for personality traits. However, having a strong SOC and high scores for personality traits was more advantageous to low-income individuals than to high-income individuals in terms of their health and quality of life; i.e., having comparable or even lower poor outcome measures (in terms of prevalence and means; resulting from a strong SOC and high personality scores) at the low-income level than at higher income levels. In other words, low-income people with strong SOC had similar functional health (OHRQoL and HRQoL) to those of high and middle-income individuals with weak SOC. Functional health (OHRQoL and HRQoL) of low-income individuals with high scores for emotional stability were similar to those of high-income level with low scores for emotional stability (Zakershahrak & Brennan, 2022). Low-income individuals with high emotional stability scores had significantly better HRQoL than those from middle-income levels with low emotional stability scores (Zakershahrak & Brennan, 2022). Furthermore, low-income individuals with strong SOC had nearly the same prevalence of poor SRGH (general health perception) as middle-income individuals with weak SOC. Also, low-income individuals with high emotional stability scores had comparable SRDH (general health perception) to those from middle-income levels but low emotional stability scores. The prevalence of low life satisfaction (overall quality of life) was comparatively lower among low-income individuals with high emotional stability scores than among high-income individuals with low emotional stability scores. These findings highlighted the advantage of having strong SOC and high scores for emotional stability for low-income groups in terms of their functional status, general health perception, overall quality of life.

Finally, findings showed that the protective psychosocial factors modified the associations between low income and health and quality of life outcome measures:

1- The associations between low-income level and poor OHRQoL and HRQoL (functional health) were modified by strong SOC and high scores for emotional stability.

2- Strong SOC modified the association between low-income level and poor SRDH and SRGH (general health perceptions). High emotional stability and agreeableness scores modified the association between low-income and poor SRDH. Also, the association between low income and poor SRGH was modified by high scores for conscientiousness.

3- The association between low income and low life satisfaction (overall quality of life) was modified by high scores for openness, agreeableness and emotional stability.

While the protective psychosocial factors modified the associations between all income levels and health and quality of life outcome measures, low-income individuals benefited more from having strong SOC and high scores for personality traits (as highlighted above) than high-income people; i.e., in terms of having greater absolute differences in prevalence and means of poor outcome measures at the low-income level than at the high-income level. The absolute difference refers to the simple difference in the outcome (i.e., prevalence and means) between two levels of protective psychosocial factors at each income level. To put it another way, low-income individuals with strong SOC and high score for personality traits (such as emotional stability) achieved greater health benefits in terms of their functional status, general health perceptions and overall quality of life than high-income people. Also, the association between income and health and quality of life outcome measures differed based on the levels of protective psychosocial factors (high and low scores for personality traits and strong and weak SOC). In other words, there were clear contrasts (in terms of prevalence and means of poor outcome measures) between the levels of protective psychosocial factors that modified the associations between income and health and quality of life. Overall, those with strong SOC and high scores for personality traits had a lower prevalence and means of poor health and quality of life outcome measures at all income levels. Different levels of protective psychosocial factors affect income inequality in relative terms. The relative differences were estimated by dividing the outcomes of individuals with high levels of protective psychosocial factors by the outcomes of individuals with low levels of these factors and then comparing the results; referring to the different income gradients in health and quality of life outcomes based on different levels of protective psychosocial factors. For instance, in study 3, individuals with strong SOC showed a steeper income gradient than individuals with weak SOC, while in study 1, individuals with strong SOC had a gentler income gradient slope. Also, high levels of protective psychosocial factors were associated with lower income disparity (lower prevalence and means of poor health and quality of life outcome measures among those low-income participants with strong SOC and high scores for personality traits). These findings provide evidence that low-income individuals could benefit more from protective psychosocial factors than high-income people.

Low-income individuals are more likely to experience stressful life situations (Evans et al., 2005; Robinette et al., 2016), affecting their health and quality of life adversely (Antonovsky, 1979, 1987). Protective psychosocial factors have been shown to be associated with better health and overall quality of life among low-income groups (Atal & Cheng, 2016; Chapman et al., 2011; Elliot et al., 2017; Mizuta et al., 2020; Packard et al., 2012; Speirs et al., 2016). Also, the modifying effect (previously referred to as the moderating effect) (Knol & VanderWeele, 2012) of SOC (Feldt, 2002) and personality traits (Chapman et al., 2007; Huang et al., 2017) on health have been reported. Besides, those with high coherence (strong SOC) and high scores for emotional stability scores (Soto & Luhmann, 2013; Super et al., 2016) are less likely to be affected by these experiences. Being emotionally stable reduces the responses to stress and the sensitivity to negative experiences (Soto & Luhmann, 2013). Also, people with high coherence reframe (reinterpret) and cope with stressors in a more meaningful, manageable, and comprehensible way (Silva et al., 2008; Volanen, 2011; Volanen et al., 2004). Therefore, these protective psychosocial factors have significant effects on health and quality of life outcome measures for low-income individuals. What I sought to articulate in this thesis was that a subset of low-income individuals, with the help of their protective psychosocial factors, such as strong SOC and high scores for personality traits, can remain healthy and maintain good quality of life.

9.2 Final considerations

Research has shown that SOC is associated with the "Big Five" personality traits (Kase et al., 2018). SOC is positively correlated with extraversion, openness, agreeableness, conscientiousness, and emotional stability (Kase et al., 2018). However, despite the similarities between SOC and personality traits, they are distinct concepts. Both of these two concepts have clearly distinct elements which do not overlap (Kase et al., 2018). Besides, SOC captures additional aspects of individuals that cannot be explained by personality traits (e.g., factors such as work-life situation, and home and family life) (Hochwälder, 2012). Also, the causal relationship between SOC and personality traits is unclear. Therefore, in this thesis, these two distinct concepts were analysed in separate studies to avoid including them together in the same models (to avoid potential collinearity and the requirement to adjust for mediators).

The presented findings were consistent with previous studies in that they highlighted the importance of the potential impact of SOC and personality traits on health and quality of life (Atal & Cheng, 2016; Chapman et al., 2011; Eriksson & Lindström, 2006; Eriksson & Lindström, 2007; Makoge et al., 2019; Mizuta et al., 2020; Speirs et al., 2016; Stephan et al., 2020). Also, personality traits have been shown to affect subjective health (perception of health ratings) and wellbeing through affectivity (positive or negative perceptions based on one's personality) (Elran-Barak et al., 2019). On the other hand, personality traits also affect objective health (i.e., professional assessment) (Elran-Barak et al., 2019; Stephan et al., 2020). The effect on objective health could be through health-promoting behaviours, leading not only to positive evaluations of health and quality of life (better outcome measures) but also to better objective health (Stephan et al., 2020). Also, low scores for some personality traits, such as emotional stability (i.e., high neuroticism scores) and low coherence (i.e., weak SOC), are not only associated with poor subjective health (negative perception of health ratings) but also with poor objective health (poor health behaviours and a number of health problems) (Elran-Barak et al., 2019; Stephan et al., 2020). However, it is still important to consider that although the outcome measures reported by individuals could be affected by their personality traits, the validity and salience of PROMs should not be overlooked. The person's perception and interpretation of their health (subjective health) are central to their health and quality of life (Elran-Barak et al., 2019); i.e., what the patient (person) think is central, which highlights the importance of PROMs. Patients' perspectives on health outcomes (collected by PROMs) are essential to support patient-centred care. These measures show people's perceptions of their health and quality of life and allow them to rate their health, functioning, symptoms, and other aspects of their health and quality of life using questionnaires (See 1.4). PROMs highlight what matters most to patients. Sharing patients' priorities (what is important to them) and their perspectives on their health, care and treatment could be an effective way to improve the quality of healthcare. Therefore, by using PROMs, three broad goals can be achieved, which are not mutually exclusive: (i) at the micro level: improving interactions and communication between clinicians and patients; (ii) at the meso level: evaluating different treatment options and their effects, and determining differences between healthcare providers; and (iii) at the macro level: public policymaking, and population monitoring and evaluation. It is possible to use PROMs for any or all of these purposes to improve the quality of healthcare. Also, as explained in the methods section (See 3.2.1.3), the PROMs used across all studies of this thesis are all valid and reliable measures. Consequently, in order to interpret the present findings in light of a multidimensional perspective on health, it is important to consider the following factors:

1- Individuals with negative affectivity are influenced by their objective health to a higher extent. Therefore, their subjective health ratings are also negatively affected (Elran-Barak et al., 2019).
2- Individuals with negative affectivity tend to rate their subjective health with great accuracy because they are accurately aware of their objective health and highly sensitive to it (Elran-Barak et al., 2019).
3- Health can be affected by protective psychosocial factors (such as personality traits) regardless of symptoms or positive affectivity (Stephan et al., 2020).

In this thesis, studies 1 to 4 applied a distributional approach to achieve a roughly even distribution of total household income to categorise income into approximate tertiles (i.e., low, middle and high-income categories). The relativity of using a distributional approach allowed comparisons between low versus medium versus high-income categories, regardless of the actual level of income (in terms of absolute thresholds). As the result, this approach facilitated the assessment of possible "dose-response" effects by enabling income gradients in health to be observed. Also, the distribution-based method took the historical time context out of income (i.e., as it focussed on the relative disparities). Using the distributional approach has the benefit of preserving the tertiles interpretation over time, whereas actual income levels may lose their meaning over time (for example, due to economic factors such as inflation). In other words, by using the distributional approach, the relativity of comparing the low-income level versus medium-income level versus high-income level is highlighted here. Also, this approach is the most parsimonious and logical way to have low, medium and high-income levels to be able to apply the results to other studies in the future. In the final study (study 5), to be consistent with other studies, middle and high-income groups were combined and considered as the high-income category and were compared to the low-income category. This approach was necessary because the final study applied a specific analysis for effect measure modification on the additive scale (by calculating the relative excess risk due to interaction (RERI)) (Knol & VanderWeele, 2012).

One of the main objectives of this thesis was to investigate the modifying effect of protective psychosocial factors (SOC and personality traits) on the association between income with health and quality of life outcome measures (the effect measure modification analysis) (VanderWeele, 2009). Categorising the protective psychosocial factors in terms of high and low coherence (strong and weak SOC) and high and low scores for personality traits allowed us to identify differences in the association between income (as the exposure) with health and quality of life outcome measures (as outcomes) based on each level of the protective psychosocial factors (i.e., personality trait dimensions as high scores or low scores) as the effect modifiers (VanderWeele, 2009). Using dichotomous categories for SOC was derived from Lundberg & Peck's (1994) valuable work. Also, personality traits served a different purpose, reflecting the differences between the psychology and epidemiology literatures. These psychological measures were used as epidemiological exposure measures across the studies in this thesis (i.e., the explanatory variable in the population-based studies) rather than clinical case definitions. According to Rothman (2008), exposure variables can be coded into categories, although there could be some disadvantages. For instance, some information might be lost, statistical power could be diminished, and adding more terms to the model might be required. However, these possible drawbacks are usually negligible or minor, particularly for large samples (Rothman et al., 2008), such as those used for all studies in this thesis (derived from the DCOHS). Also, categorising the exposure variable allows estimation of the effects of each stratum of exposure without being constrained by any particular pattern (Rothman et al., 2008):

"The advantage of the unconstrained estimation of separate effects outweighs the disadvantages in most situations".

Also, when individuals were dichotomised according to their personality traits, this allowed us to determine each individual's direction towards each end of the personality spectrum (expressing each trait at a high or low level/score) (Zakershahrak & Brennan, 2022). In other words, by dichotomising personality traits (as dichotomous variables), the focus from the homogeneity of personality traits (as variables) was shifted to the individual differences (as participants) (Richters, 1997).

Dichotomising personality traits allowed us to identify how many individuals possess a particular explanatory variable (i.e., each personality trait) or the combination of explanatory variables (income levels and levels of each personality trait) and determine what specific explanatory variables affect individuals (i.e., what level of income and personality traits) (Zakershahrak & Brennan, 2022). For example, we were able to answer the questions such as: how many low-income individuals had high scores for personality traits? Do high scores for personality traits affect low-income people's health outcomes? Also, it was possible to investigate how the association between the exposure variable (income) and outcomes (poor health and quality of life outcome measures) differed across the strata of the effect modifiers (high scores versus low scores for personality traits) (Zakershahrak & Brennan, 2022). It is important to consider types of individuals rather than assuming homogeneity with regard to psychological variables such as personality traits (Zakershahrak & Brennan, 2022). Also, what matters is not the participants' literal answers to each of the questions in the TIPI items (See 3.2.1.2.2), but whether the pattern of responses to a series of questions fits into the category of individuals who exhibit that personality trait (Zakershahrak & Brennan, 2022). Therefore, a conceptual decision was required for personality traits and about the cut-off point for showing where each individual fits in the continuum spectrum of each trait (i.e., towards which end of the spectrum). The conceptual cut-off point divided the trait scale based on the scores equal to being "agree" or higher (on average) and created two categories: low scores for personality traits and high scores for personality traits (See 3.2.1.2.2). This conceptual approach has face validity. Also, it is easier to interpret and more meaningful to policymakers and a broader audience.

VanderWeele et al. (2011) stated: "This feature of being able to avoid misspecification of the outcome model in interaction analyses is a potential argument in favor of dichotomization." For interaction terms, interpreting continuous exposure results (the effect modifier) is difficult for a wider audience, particularly when psychological variables are used (DeCoster et al., 2011). The process of performing simple effect tests and graphing the means of each level (using categorical exposures) is usually much easier than assessing the interaction using continuous exposures (with simple slopes) (DeCoster et al., 2011). These simple slopes need to be computed by substituting the appropriate values into the estimated regression equation (and not through the regression analysis) (DeCoster et al., 2011). On the other hand, the problem with a continuous variable is that the model's assumptions are potentially broken. As the psychological factors, such as personality traits (the continuous variable), are often not uniformly linear across the range of the distribution, the model may not be linear. Also, when a continuous variable is used, the coefficient resulting from the regression model is assumed to be uniform - a unit increase is uniform across the entire range of that continuous variable. Therefore, it requires the assumption that each unit has exactly the same relationship all the way across the range; i.e., one has to assume the relationship is continuous across that entire fitted line. However, there is the possibility that different relationships may hold across the range of the continuous variable (e.g., with thresholds at particular points). Thus, the adoption of a categorical variable makes fewer assumptions about the uniformity of the relationship.

Categorisation has been widely applied by psychopathology researchers for statistical reasons (DeCoster et al., 2011). The statistical benefits of categorising variables facilitate the interpretation of variables, analyses, and study results, particularly for a broad audience (DeCoster et al., 2011). By categorising variables, it is possible to compare differences between groups instead of across a continuum, simplifying the variable's interpretation (DeCoster et al., 2011). In psychological research, categorical predictors and exposures are most commonly used to test influences on outcomes using ANOVA analysis (DeCoster et al., 2011). A graph or table displaying the mean scores of different groups is the simplest way to show significant effects. Also, the interpretation of the effects based on the slope of the exposure-outcome gradient and its changes based on the other exposure using a continuous variable is more complex than a categorical variable (DeCoster et al., 2011). By categorisation, we are able to simply compare the difference between outcome ratings for categorical groups of exposure based on different levels of the other exposure (i.e., effect modification).

A common technique used in psychological research to examine the relationship between exposure and outcome - when at least exposure is continuous - is the extreme group approach (EGA) (Preacher et al., 2005). EGA is a sampling strategy to select individuals based on their extreme scores of exposures (typically upper and lower tertiles or quartiles), then examine the relationship between exposure and outcome only for those individuals (which has its own disadvantages) (Preacher et al., 2005). Alternatively, instead of using EGD, psychological researchers collect data using measures that produce continuous variables/scores and create categorical group variables from them (e.g., creating high- and low-score groups) (DeCoster et al., 2011). Categorising the continuous variables enhances the interpretability of their results and makes these variables more meaningful and understandable for policymakers (DeCoster et al., 2011). Also, Farrington and Loeber (2000) showed that the gains in interpretability that categorisation provided were outweighed by the costs in terms of power (which were relatively small).

Finally, it is impossible to create a model that encompasses all relevant predictors of outcomes in social and behavioural science (Neter et al., 1996). A model's predictive value should be optimised by including a variety of covariates that add unique information to the model (Marill, 2004). Nonetheless, one should avoid overlap between different covariates and multicollinearity, which occurs when there are too few or too many variables in the model (Marill, 2004). Also, correlated covariates should not be included in the models because their inclusion increases the standard error of the estimated regression coefficients (Krzywinski & Altman, 2015). Limiting the covariates and choosing the most important ones has significant benefits, namely: simplifying both the interpretation and multiple testing, and preventing overfitted models (which despite their good fit, have poor predictions) (Krzywinski & Altman, 2015). Accordingly, across all studies of this thesis, the covariates were chosen according to the general concept of health behaviours in order to encompass their different dimensions. The covariates represented four different conceptual factors: preventative behaviour (tooth brushing), risky behaviour (smoking), utilisation of health service (last dental visit), and enabling factors (dental insurance). It should be noted that these variables tend to cluster together rather than occur separately (Alzahrani et al., 2014; Sanders et al., 2005). Therefore, in this thesis, the number of covariates in the models was deliberately limited to the most relevant health behaviour covariates to avoid overlapping health behaviour variables and overfitting the models.

9.3 Strengths

One of the main strengths of this thesis is that a large and state-representative dataset (DCOHS) was used across all studies, strengthening the broader applicability, generalisability and universality of the findings. Also, each study used a relatively large sample that was representative of the study population. All studies analysed data using four similar multivariate models to assess the consistency and similarity of patterns and associations among models. Also, different statistical analysis techniques were used to fully utilise the potential of the available data in this thesis. The findings of all studies were interpreted based on the effect size and the direction of effect modification and interactions. Particularly, the final study had the advantage of estimating the interactions on both additive and multiplicative scales. Furthermore, the DCOHS comprises psychometrically validated and reliable scales for collecting SOC and personality traits (See 3.2.1.2.1 and3.2.1.2.2 3.2.1.2.2). Also, in the DCOHS, valid and standard PROMs were used for assessing health and quality of life outcome measures (See 3.2.1.3).

9.4 Limitations

All studies of this thesis had common limitations, namely the cross-sectional design of the study and the moderate response rate in the DCOHS (44.8%). Despite that, cross-sectional studies suggest possible associations between exposure (risk factor) and outcome, although the temporal relationship between the exposure of interest and outcome is often difficult to determine. However, the analysis of large cross-sectional representative samples provides valuable insight into the population's health status and healthcare needs over time. Also, over the past three decades, the response rates for surveys have commonly been below 50% (Baruch & Holtom, 2008). Besides, there was a minimal probability of response bias, as the final samples used in each study had similar characteristics to the DCOHS and to the respondents that were excluded from the analysis (because of missing responses). As mentioned previously (See 3.1.1), the DCOHS participants were drawn at random from the Electoral Roll. Due to Australia's compulsory voting system, the Electoral Roll is a large and comprehensive sampling frame. Additionally, similar to previous research (Song et al., 2020a; Song et al., 2020b), the DCOHS was broadly representative of the age and sex distributions of the adult population in South Australia.

9.5 Study implications and future directions

A potential implication of the findings is to consider the effect and importance of protective psychosocial factors in ameliorating income-health disparities, particularly for low-income groups. The findings suggest that interventions targeting protective psychosocial factors can be incorporated into effective multidimensional programs addressing income-health disparities. Since SES and psychosocial factors are intimately intertwined, tackling SES-health inequalities could be strengthened through broader SES-targeted interventions and anti-poverty social policies supported by protective psychosocial factors. My studies provided evidence suggesting low-income individuals could achieve greater gains (in absolute terms) from strengthening protective psychosocial factors related to better health and quality of life than other income groups, despite their socioeconomic disadvantages. Among these strengthening approaches are salutogenic interventions (Suárez Álvarez et al., 2022) and empowerment strategies (e.g., targeting personality traits linked to risky behaviours (Edalati & Conrod, 2019), positive psychology (Appiah et al., 2020), and mental health promotion (Castillo et al., 2019)). However, action must be taken to provide adequate funding and effective management to implement these approaches as long-term community programs successfully. Also, to establish causal relationships, future research is needed to investigate the effect of protective psychosocial factors on SES-health associations in other study designs, such as longitudinal and experimental studies.

9.6 Conclusions

In general, this thesis investigated the influence of protective psychosocial factors (SOC and personality traits) on income gradients in self-reported health and quality of life following the conceptual guidelines of Wilson and Cleary's model. Findings showed positive cross-sectional associations between protective psychosocial factors (SOC and personality traits) and better oral and general health and quality of life outcome measures. At all income levels, these factors were protective against poor self-reported health and quality of life. Also, the modifying effect of protective psychosocial factors (SOC and personality traits) was associated with lower levels of poor self-reported oral and general health and quality of life outcome measures at all income levels. Findings suggested that having protective psychosocial factors, such as strong SOC and high emotional stability scores, had greater health and quality of life gains for low-income individuals than for high-income individuals. Also, given that oral health is associated with general health, similar relationships were observed in effect modifications, main effects, and the interaction effects between income and the protective psychosocial factors (SOC and personality traits) in both oral and general health measures.

Findings suggest that multidimensional approaches (e.g., interventions) incorporating protective psychosocial factors could be more efficient in addressing health inequalities. Other study designs, such as longitudinal and experimental studies, are needed to investigate the role of protective psychosocial factors in the association between SES and health.

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Table 9.1 Summary of main findings across five studies in the thesis

	Functional Status		General Health Perception		Overall Quality of life
	Poor OHIP-14¶	Poor EQ-5D¶	Poor SRDH¶	Poor SRGH¶	Low SWLS¶
Model 1†					
Low Psychosocial factors	🡅$^{\text{S, C, ES}}$	🡅$^{\text{S, C, ES}}$	🡅$^{\text{E, A, C}}$	🡅$^{\text{S, C, ES}}$	🡅$^{\text{E, O, A, C, ES}}$
Low-income group	🡅	🡅	🡅	🡅	🡅
Interaction	✓ S, ES	✓ S, ES	✓ E	✓ C	✓ C
Model 2†					
Low Psychosocial factors	🡅$^{\text{S, ES}}$	🡅$^{\text{S, C, A, ES}}$	🡅$^{\text{E, A, C}}$	🡅$^{\text{S, C, ES}}$	🡅$^{\text{E, O, A, C, ES}}$
Low-income group	🡅	🡅	🡅	🡅	🡅
Interaction	✓ S, ES	✓ S, ES	✓ E	✓ C	✓ E, C, ES
Model 3†					
Low Psychosocial factors	🡅$^{\text{S, ES}}$	🡅$^{\text{S, C, ES}}$	🡅$^{\text{E, A, C}}$	🡅$^{\text{S, C, ES}}$	🡅$^{\text{E, O, A, C, ES}}$
Low-income group	🡅	🡅	🡅	🡅	🡅
Interaction	✓ S, ES	✓ S, ES	✓ E	✓ C	✓ E, C, ES
Model 4†					
Low Psychosocial factors	🡅$^{\text{S, ES}}$	🡅$^{\text{S, C, ES}}$	🡅$^{\text{E, A, C}}$	🡅$^{\text{S, C, ES}}$	🡅$^{\text{E, O, A, C, ES}}$
Low-income group	🡅	🡅	🡅	🡅	🡅
Interaction	✓ S	✓ S, ES	✓ E	✓ C	✓ E, C, ES
Modifying effect of high psychosocial factors §	🡇$^{\text{S, ES}}$	🡇$^{\text{S, ES}}$	🡇$^{\text{S, A, ES}}$	🡇$^{\text{S, C}}$	🡇$^{\text{O, A, ES}}$

† Model 1: crude model (unadjusted);
Model 2: adjusted for sex and age;
Model 3: adjusted for all Sociodemographic characteristics (sex, age, main language spoken at home and birthplace);
Model 4: adjusted for Sociodemographic characteristics (sex, age, main language spoken at home and birthplace) and Health behaviour variables (daily tooth brushing, smoking status, dental insurance and last dental visit).
¶ OHIP-14: Oral Health Impact Profile; EQ-5D: European Quality of Life indicator; SRDH & SRGH: self-rated dental and general health (respectively); SWLS: Satisfaction With Life Scale.
§ Effect measure modification of high psychosocial factors on the association between different income levels and poor patient-reported outcome measures.
🡅 Main effect (i.e., associated with a higher outcome).
✓ Observed measure of interaction between the low-income group and low psychosocial factors on a multiplicative scale.
🡇 Modifying effect of high psychosocial factors was associated with a lower outcome at all income levels (with a greater effect of the high psychosocial factor for low-income group vs high-income group).
P Personality trait: **E** Extraversion; **O** Openness; **A** Agreeableness; **C** Conscientiousness; **ES** Emotional Stability; Low and high psychosocial factors referred to low and high scores for these traits, respectively.

S Sense of coherence: Low and high psychosocial factors referred to the weak and strong sense of coherence, respectively (i.e., low and high coherence, respectively; in terms of the relative strength of the concept of sense of coherence). Since the sense of coherence was not modelled with SWLS, it does not appear in the last column.

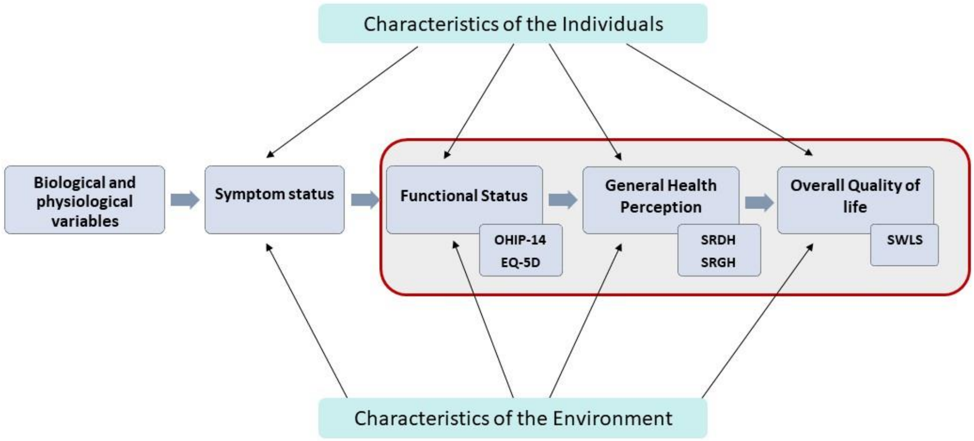

Figure 9.1 The five studies of this thesis used the patient-reported outcome measures in the same order as the underlying health concepts in Wilson and Cleary's conceptual model (functional status: Oral Health Impact Profile (OHIP-14), and European Quality of Life indicator or EuroQol (EQ-5D); general health perception: self-rated dental and general health (SRDH and SRGH, respectively); and overall quality of life: Satisfaction With Life Scale (SWLS)).

Thesis appendices

Appendix 1. Models for the effects of sense of coherence (SOC) on the overall quality of life (measured using SWLS)

Following the final study (study 5, See Chapter 8), the presented models explored the main effects and interaction effects of SOC and income on life satisfaction.

Four multivariable Poisson regression models (generalised linear model with a log-Poisson link and robust error) were applied to investigate the associations (main effects) between SOC and household income levels (exposure variable) and their interaction effects with the overall quality of life, measured using SWLS (outcome).

The main effects of SOC and income on life satisfaction were observed (Appendix Table 1). Weak SOC (i.e., low coherence in terms of the relative strength of the concept of SOC) were significantly associated with low life satisfaction (PR=3.4, for the unadjusted model and models adjusted for sociodemographic variables; PR=3.2, for the fully adjusted model; representing the greater effect of SOC for life satisfaction). The interaction effect of weak SOC at the low-income level (PR=0.8, in adjusted models) showed a relatively greater effect for SOC at the high-income level (reflecting the lower prevalence of low life satisfaction for high-income respondents with strong SOC).

Appendix Table 1. Prevalence ratios of main effects and interaction between the sense of coherence and income with low life satisfaction

	Model 1[a]	Model 2[s]	Model 3[c]	Model 4[d]
	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)	PR (95%C.I.)
Sense Of Coherence *(Ref. Category: Higher Coherence (Strong SOC))*	3.4**(2.9-4.0)	3.4**(2.9-4.0)	3.4**(2.9-4.0)	3.2**(2.7-3.8)
Low-Income Category *(Ref. Category: High Income Category)*	1.7**(1.4-2.1)	2.0**(1.6-2.5)	2.0**(1.6-2.5)	1.9**(1.5-2.3)
Interaction of Low-Income Category and Lower Coherence (Weak SOC)	0.8^{NS}(0.6-1.0)	0.8* (0.6-1.0)	0.8* (0.6-1.0)	0.8* (0.6-1.0)

** P<0.01
* P<0.05
NS: Not Significant

Ref. Category*:* Reference Category
PR: Prevalence Ratios
SOC: Sense of coherence

a: Model 1 comprised the interactions of SOC with different income groups and the main effects of income and SOC (crude model; unadjusted).
b: Model 2 adjusted for sociodemographic variables: sex and age.
c: Model 3 adjusted for all sociodemographic variables: sex, age, the main language spoken at home, and country of birth.
d: Model 4 adjusted for all sociodemographics (sex, age, the main language spoken at home and country of birth) and all health behaviour variables (daily toothbrushing, smoking, dental insurance and last dental visit).

Appendix 2. DCOHS questionnaire

THE UNIVERSITY of ADELAIDE

AUSTRALIAN RESEARCH CENTRE FOR POPULATION ORAL HEALTH
SCHOOL OF DENTISTRY

DENTAL CARE AND ORAL HEALTH STUDY

The purpose of this study is to answer fundamental questions on what works best in relation to the provision of dental care. The study involves collection of responses to a questionnaire from a sample of Australian adults aged over 18 years. The questionnaire will take about **20 minutes** to complete.

Why participate?

1. The study provides evidence to a National Strategic Plan Priority Area on health systems development.
2. This is a major study that tracks your health outcomes and dental care over time.
3. Results of the study will be available on a project website (more information provided at end of this survey).

How to complete the survey?

1. Please use a DARK pen to write your answers.
2. Please use BLOCK LETTERS.
3. Responses can be provided by:
   - Marking with a CROSS (eg. ☒)
   - Circling a number (eg. ①)
   - Writing the response (eg. MOBILE DENTAL CLINIC)

Instructions are also provided at the beginning of each question.

4. There are three parts to the survey:
   PART A asks questions about oral health.
   PART B asks questions about general health.
   PART C asks questions about your background, education and work.
5. Answer all questions, unless otherwise indicated.

Your feedback is strictly confidential

1. Results will be reported as group profiles only.
2. Individual identity will not be revealed.

Any queries

Dental care and oral health study
Health Services Research Unit
Contact: Madhan Balasubramanian
Tel: 08 83135027 Fax: 08 83133070
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Conducted by:

Health Services Research Unit
Australian Research Centre for Population Oral Health (ARCPOH)
School of Dentistry, The University of Adelaide

Please return the completed questionnaire as soon as possible in the reply paid envelope provided

PART A contains questions about your oral health status, dental visits, dental insurance, financial burden due to dental care, impact of oral health on your daily life and issues related to your satisfaction with dental care and the dental system in Australia. Instructions on how to answer each question are provided at beginning of the question.

1 Tooth brushing habits [Please mark with a CROSS or WRITE your answer, where required]

A. In the last week, how many times did you brush your teeth? ____________ (times) → **If NIL go to Question 1 D now**

B. If you said you brushed your teeth at least once a week, how long on average do you spend on brushing your teeth?

- ☐ Less than one minute
- ☐ About one minute
- ☐ About 1½ minutes
- ☐ About 2 minutes
- ☐ About 2½ minutes
- ☐ About 3 minutes
- ☐ More than 3 minutes

C. In the last week, how many times did you use an electric tooth brush? ____________ (times)

D. In the last week, how many times did you use dental floss? ____________ (times)

E. In the last week, how many times did you use a mouth rinse/wash? ____________ (times)

F. If you used a mouth rinse or mouth wash, write the name of the product you used here: ________________________

2 Number of teeth [Please mark with a CROSS or WRITE your answer, where required]

A. Do you have any of your own natural teeth?

- ☐ Yes, I have some or all of my natural teeth
- ☐ No, I have none of my natural teeth → **If NO go to Question 3 now**

B. There are 16 teeth, including wisdom teeth, in the UPPER jaw. How many of these 16 teeth do you have in your upper jaw? *Do not count false teeth. If you have no teeth in your upper jaw write 'nil'.*

I have ________ (number) of teeth in my UPPER jaw.

C. There are 16 teeth, including wisdom teeth, in the LOWER jaw. How many of these 16 teeth do you have in your lower jaw? *Do not count false teeth. If you have no teeth in your lower jaw write 'nil'.*

I have ________ (number) of teeth in my LOWER jaw.

3 Dentures [Please mark with a CROSS]

Dentures are artificial teeth that can be removed.

A. Do you wear a denture in your UPPER jaw? ☐ Yes ☐ No

B. Do you wear a denture in your LOWER jaw? ☐ Yes ☐ No

4 Oral and general health [Please mark with a CROSS]

A. How would you rate your dental health? ☐ Excellent ☐ Very good ☐ Good ☐ Poor ☐ Very poor

B. How would you rate your general health? ☐ Excellent ☐ Very good ☐ Good ☐ Poor ☐ Very poor

5 Dental visits [Please mark with a CROSS or WRITE your answer, where required]

A. When was your last visit to a dental professional?
(Includes dentist, dental specialist, oral health therapist, dental hygienist, dental therapist, dental technician, denturist or dental prosthetist)

- ☐ Less than 12 months ago
- ☐ One to less than two years ago
- ☐ Two to less than five years ago
- ☐ Five to less than ten years ago
- ☐ Ten years or more
- ☐ Never attended → **Go to Question 6**

B. What was the main reason for your last dental visit?

- ☐ Examination or check-up
- ☐ Treatment (not for relief or pain)
- ☐ Emergency/relief of pain

C. How often do you usually seek care from a dental professional?
(Includes dentist, dental specialist, oral health therapist, dental hygienist, dental therapist, dental technician, denturist or dental prosthetist)

- ☐ More than two times a year
- ☐ Two times a year
- ☐ Once a year
- ☐ Once every two years
- ☐ Less often than once every two years

D. Where did you go for your last dental visit?

- ☐ Private dental practice
- ☐ Public dental clinic (including dental hospital, community clinic)

E. Please write the name of the suburb or postcode of the clinic where you made your last dental visit ?

__________ suburb OR ☐☐☐☐ postcode

F. Overall, how many...

		In the last 12 months	One year to two years ago
1	**...dental appointments have you attended..........**		
2	**...dental examinations have you had..........**		
3	**...clean and scale procedures have you had..........**		
4	**...fillings have you had..........**		
5	**...teeth have you had extracted (removed)..........**		

G. Have you had any other dental treatment in the last 12 months?
[Cross the relevant box(es)]

- ☐ No other treatment in the last 12 months
- ☐ Professional fluoride application
- ☐ New denture(s) prepared or fixed
- ☐ Oral surgery (besides extraction)
- ☐ Other treatment (please specify) __________
- ☐ Gum treatment (periodontal treatment)
- ☐ Adjustment, reline or rebase denture(s)
- ☐ Orthodontics
- ☐ Crown or bridge treatment

6 Future dental visits [Please mark with a CROSS]

A. Do you need to make a dental visit now? ☐ Yes ☐ No → **If NO go to Question 7 now**

B. What do you need the dental visit for? ☐ Check-up ☐ Treatment (not for relief of pain) ☐ Emergency/relief of pain

C. How soon do you think you need a check-up or treatment?

- ☐ In less than a week
- ☐ From one week to less than a month
- ☐ From one month to less than three months
- ☐ From three months to less than six months
- ☐ Six months or more

7 Financial burden [Please mark with a CROSS or CIRCLE your answer, where required]

A. During the last 12 months, have you avoided or delayed visiting a dental professional because of cost? ☐ Yes ☐ No

B. Has cost prevented you from having any dental treatment that was recommended by a dental professional? ☐ Yes ☐ No

> Did you take up an alternative lower cost option for the treatment that was recommended? ☐ Yes ☐ No

> Which dental treatments were prevented by cost?

(Please CROSS as many as applicable)

- ☐ Fillings
- ☐ Extractions
- ☐ Scale and clean
- ☐ Dental implants
- ☐ Gum treatments (periodontal)
- ☐ Dental crown or bridge
- ☐ Root canal
- ☐ Dentures made
- ☐ Orthodontic treatment
- ☐ Cosmetic treatment (eg. bleaching)
- ☐ Replace amalgams with white
- ☐ Others

C. In the last 12 months how much of a financial burden have dental visits been to you? ☐ None ☐ Hardly any ☐ A little ☐ A large burden

D. At most times of the year, how much difficulty would you have paying a **$150 bill** out of your own pocket? ☐ None ☐ Hardly any ☐ A little ☐ A lot

E. Overall, how satisfied are you with your current financial situation?

Totally dissatisfied … *Totally satisfied*

0	1	2	3	4	5	6	7	8	9	10

F. Overall, how satisfied are you with the material standards of your life?

Totally dissatisfied … *Totally satisfied*

0	1	2	3	4	5	6	7	8	9	10

G. Relative to others, how would you rate your financial position?

Worse than most … *Better than most*

0	1	2	3	4	5	6	7	8	9	10

H. Do you hold any of these concession cards?

- ☐ Health Care Card
- ☐ Pensioner Concession Card
- ☐ Commonwealth Seniors Card
- ☐ Other card
- ☐ None of the above
- ☐ Don't know

I. Do you have private health insurance (including hospital or ancillary/extras insurance, excluding Medicare)

☐ Yes, I have private health insurance ☐ No, I do not have private health insurance

> What best describes your private health insurance status?

- ☐ Combined hospital & ancillary/extras cover
- ☐ Hospital cover only
- ☐ Ancillary/extras only cover

8 Impact of oral health on your daily life

HOW OFTEN during the PAST YEAR

Please CIRCLE	Never 1	Hardly ever 2	Occasionally 3	Fairly often 4	Very often 5
1. Have you had **trouble pronouncing any words** because of problems with your teeth, mouth or dentures?	1	2	3	4	5
2. Have you felt that your **sense of taste has worsened** because of problems with your teeth, mouth or dentures?	1	2	3	4	5
3. Have you had **painful aching** in your mouth?	1	2	3	4	5
4. Have you found it **uncomfortable to eat any foods** because of problems with your teeth, mouth or dentures?	1	2	3	4	5
5. Have you been **self-conscious** because of your teeth, mouth or dentures?	1	2	3	4	5
6. Have you **felt tense** because of problems with your teeth, mouth or dentures?	1	2	3	4	5
7. Has your **diet been unsatisfactory** because of problems with your teeth, mouth or dentures?	1	2	3	4	5
8. Have you had to **interrupt meals** because of problems with your teeth, mouth or dentures?	1	2	3	4	5
9. Have you found it **difficult to relax** because of problems with your teeth, mouth or dentures?	1	2	3	4	5
10. Have you been a **bit embarrassed** because of problems with your teeth, mouth or dentures?	1	2	3	4	5
11. Have you been a **bit irritable** with other people because of problems with your teeth, mouth or dentures?	1	2	3	4	5
12. Have you had **difficulty doing your usual jobs** because of problems with your teeth, mouth or dentures?	1	2	3	4	5
13. Have you felt that **life in general was less satisfying** because of problems with your teeth, mouth and dentures?	1	2	3	4	5
14. Have you been **totally unable to function** because of problems with your teeth, mouth or dentures?	1	2	3	4	5
15. Have you had **pain** in the face, jaw, temple, in front of ear, or in the ear?	1	2	3	4	5
16. Have you **broken or chipped** a natural tooth?	1	2	3	4	5
17. Have you had **sensitive teeth**, for example due to hot or cold food or drinks?	1	2	3	4	5
18. Have you had any teeth that have become **loose** by themselves without some injury?	1	2	3	4	5
19. Have you had **sore gums**?	1	2	3	4	5

9 Dental fear [Please CROSS the appropriate box]

Do you feel afraid or distressed when going to the dentist?	Not at all ☐	A little afraid or distressed ☐	Moderately afraid or distressed ☐	Very afraid or distressed ☐	Extremely afraid or distressed ☐

10 Dentist trust

These questions relate to Dentist Trust. In general...

Please CIRCLE a number for each statement

	Strongly disagree				Strongly agree
1. Dentists care about their patients' health just as much or more as their patients do.	1	2	3	4	5
2. Sometimes dentists care more about what is best for them, than about patients dental needs.	1	2	3	4	5
3. Dentists are extremely thorough and careful.	1	2	3	4	5
4. You completely trust dentists decisions about which dental treatments are best.	1	2	3	4	5
5. Dentists think only about what is best for their patients.	1	2	3	4	5
6. Dentists are totally honest in telling their patients about all the different treatment options available for their conditions.	1	2	3	4	5
7. Sometimes dentists do not pay full attention to what patients are trying to tell them.	1	2	3	4	5
8. Dentists always use their very best skills and effort on behalf of their patients.	1	2	3	4	5
9. You have no worries about putting your oral health in the hands of the dentist.	1	2	3	4	5
10. A dentist would never mislead you about anything.	1	2	3	4	5
11. All in all, you trust dentists completely.	1	2	3	4	5

11 Dental care satisfaction

A. Have you ever visited a dentist before? ☐ Yes ☐ No → **If No, Go to Question 12 now**

B. These questions relate to your LAST DENTAL VISIT.

Please CIRCLE a number for each statement

	Strongly disagree				Strongly agree
1. I was satisfied with the dental care I received.	1	2	3	4	5
2. I would like to have had more explanation of my dental treatment options.	1	2	3	4	5
3. The dental surgery had everything needed to provide my dental care.	1	2	3	4	5
4. The dental care I received did not improve my dental health.	1	2	3	4	5
5. I was able to make the dental visit as promptly as I felt was necessary.	1	2	3	4	5
6. The dental professional explained whether there were any patient costs and how much, before beginning the treatment.	1	2	3	4	5
7. The dental professional I saw explained well what treatment was needed.	1	2	3	4	5
8. I am confident that I received good dental care at my last visit.	1	2	3	4	5
9. There are things about dental care I received that could have been better.	1	2	3	4	5

PART B asks questions about your general health and impact of general health on your daily life. Instructions on how to answer each question are provided at beginning of each question.

12 General health information [Please mark with a CROSS or WRITE where required]

A. What is your current HEIGHT? ______ centimetres OR ___/___ feet / inches

B. What is your current WEIGHT? ______ kilograms OR ______ pounds

C. Do you have any of these chronic medical conditions? [Please CROSS all that apply]

1. Asthma	☐	9. Cataracts	☐	17. Hypothyroidism	☐
2. Chronic bronchitis or emphysema	☐	10. Glaucoma	☐	18. Rheumatic fever	☐
3. Hypertension or high blood pressure	☐	11. Osteoporosis	☐	19. A bleeding problem	☐
4. A heart condition or heart attack	☐	12. Hip fracture	☐	20. Deafness	☐
5. High cholesterol	☐	13. A cancer or malignancy	☐	21. Diagnosed with dementia	☐
6. A stroke or "mini strokes" (TIA)	☐	14. A diagnosed depression	☐	22. Diagnosed with Alzheimer's disease	☐
7. Diabetes	☐	15. Parkinson's disease	☐	23. Artificial joints, heart valves or prosthesis	☐
8. Arthritis	☐	16. Epilepsy	☐	24. Other medical conditions (please specify) ______	☐

D. Which of these statements best describe your cigarette smoking status?

- ☐ I smoke daily → A)
- ☐ I smoke occasionally → A)
- ☐ I do not smoke now but I used to → B)
- ☐ I have never smoked

A) On average, I smoke _____ (number) cigarettes per day.

B) I used to smoke ____(number) cigarettes per day.

C) I stopped smoking _____ years ago.

13 Your general health today [Please CROSS one box only for each question]

A. MOBILITY	I have no problems walking about.	☐	I have some problems walking about.	☐	I am confined to bed.	☐
B. SELF CARE (eg. Washing, dressing)	I have no problems with self care.	☐	I have some problems with washing and dressing myself.	☐	I am unable to wash or dress myself.	☐
C. USUAL ACTIVITIES (eg. household work, family, leisure)	I have no problems performing my usual activities.	☐	I have some problems performing my usual activities.	☐	I am unable to perform my usual activities.	☐
D. PAIN/DISCOMFORT	I have no pain or discomfort.	☐	I have moderate pain or discomfort.	☐	I have extreme pain or discomfort.	☐
E. ANXIETY/DEPRESSION	I am not anxious or depressed.	☐	I am moderately anxious or depressed.	☐	I am extremely anxious or depressed.	☐

14 Life satisfaction, social support and work [Please CIRCLE a number that best represents your perspective]

A. The following statements seek views on levels of life satisfaction	Strongly disagree				Strongly agree
1. In most ways my life is close to my ideal.	1	2	3	4	5
2. The conditions of my life are excellent.	1	2	3	4	5
3. I am satisfied with my life.	1	2	3	4	5
4. So far I have acquired the important things I want in my life.	1	2	3	4	5
5. If I could live my life over, I would change almost nothing.	1	2	3	4	5

B. The following statements are about social support.	Strongly disagree				Strongly agree
1. There is a special person who is around when I am in need.	1	2	3	4	5
2. There is a special person with whom I can share joys and sorrows.	1	2	3	4	5
3. My family really tries to help me.	1	2	3	4	5
4. I get the emotional help and support I need from my family.	1	2	3	4	5
5. I have a special person who is a real source of comfort to me.	1	2	3	4	5
6. My friends really try to help me.	1	2	3	4	5
7. I can count on my friends when things go wrong.	1	2	3	4	5
8. I can talk about my problems with my family.	1	2	3	4	5
9. I have friends with whom I can share my joys and sorrows.	1	2	3	4	5
10. There is a special person in my life who cares about my feelings.	1	2	3	4	5
11. My family is willing to help me make decisions.	1	2	3	4	5
12. I can talk about my problems with my friends.	1	2	3	4	5

C. The following statements are about your work.
Paid work, study and volunteering are considered 'work'.

IFYOU ARE NOT WORKING CURRENTLY GO TO QUESTION 15 NOW

	Strongly disagree				Strongly agree
1. After work, I am too tired for leisure activities, family time or house chores.	1	2	3	4	5
2. I have so much work to do that it takes away from my personal interests.	1	2	3	4	5
3. My family/friends dislike how often I am preoccupied with work while I am at home.	1	2	3	4	5
4. Work takes up time that I'd like to spend with family or friends.	1	2	3	4	5
5. I am often too tired at work because of the things I have to do at home.	1	2	3	4	5
6. My superiors and peers dislike how often I am preoccupied with my personal life while at work.	1	2	3	4	5
7. My personal demands are so great that they interfere with my work.	1	2	3	4	5
8. My personal life takes up time that I'd like to spend at work.	1	2	3	4	5

15 General health [Please CIRCLE a number that best represents your perspective]

A. The following statements are about your general health.	Strongly disagree				Strongly agree
1. I take responsibility in caring for my health.	1	2	3	4	5
2. No matter how hard I try my health does not turn out the way I would like.	1	2	3	4	5
3. It is difficult for me to find effective solutions to health problems that come my way.	1	2	3	4	5
4. I succeed in the projects I undertake to improve my health.	1	2	3	4	5
5. I am generally able to achieve my goals with respect to health.	1	2	3	4	5
6. I am usually unsuccessful in making changes to things about my health that I don't like.	1	2	3	4	5
7. Generally, my plans for my health don't work out well.	1	2	3	4	5
8. I am able to do things for my health as well as most other people.	1	2	3	4	5

B. The following statements ask questions about stress. While answering Can you please consider " How often during the Past year…"

	Very often	Fairly often	Occasionally	Hardly ever	Never
Please CIRCLE	1	2	3	4	5
1. Have you felt upset because of something that happened unexpectedly?	1	2	3	4	5
2. Have you felt unable to control the important things in life?	1	2	3	4	5
3. Have you felt either nervous or stressed?	1	2	3	4	5
4. Have you dealt successfully with irritating life hassles?	1	2	3	4	5
5. Have you effectively coped with important changes in your life?	1	2	3	4	5
6. Have felt confident about your ability to handle your personal problems?	1	2	3	4	5
7. Have you felt things were not going your way?	1	2	3	4	5
8. Have you felt unable to cope with all things that you had to do?	1	2	3	4	5
9. Have you felt able to control irritations in your life?	1	2	3	4	5
10. Have you felt you were on the top of things?	1	2	3	4	5
11. Have you felt angered because of things that happened outside your control?	1	2	3	4	5
12. Have you found yourself thinking about all the things that you have to accomplish?	1	2	3	4	5
13. Have you felt able to control the way you spend your time?	1	2	3	4	5
14. Have you felt difficulties were piling up so high that you could not overcome them?	1	2	3	4	5

16 Social and health system values [Please CIRCLE a number that best represents your opinion]

	Strongly disagree				Strongly agree
1. The community is responsible for ensuring everyone is able to receive dental care.	1	2	3	4	5
2. People with similar dental problems should be provided with the same dental care.	1	2	3	4	5

17 **Personality traits** [Please CIRCLE the number that best represents your answer]

Here are a number of personality traits that may or may not apply to you. Please indicate the extent to which you agree or disagree with each statement. You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other.

I see myself as:	Disagree strongly	Disagree moderately	Disagree a little	Neither agree or disagree	Agree a little	Agree moderately	Agree strongly
1. Extraverted, enthusiastic	1	2	3	4	5	6	7
2. Critical, quarrelsome	1	2	3	4	5	6	7
3. Dependable, self-disciplined	1	2	3	4	5	6	7
4. Anxious, easily upset	1	2	3	4	5	6	7
5. Open to new experiences, complex	1	2	3	4	5	6	7
6. Reserved, quiet	1	2	3	4	5	6	7
7. Sympathetic, warm	1	2	3	4	5	6	7
8. Disorganised, careless	1	2	3	4	5	6	7
9. Calm, emotionally stable	1	2	3	4	5	6	7
10. Conventional, uncreative	1	2	3	4	5	6	7

18 **Orientation to life** [Please CIRCLE the number that best represents your answer]

Do you usually:	Yes, usually	Yes, sometimes	No
1. Feel that the things that happen to you in your life are hard to understand?	1	2	3
2. See a solution to problems and difficulties that other people find hopeless?	1	2	3
3. Feel that your daily life is a source of personal satisfaction?	1	2	3

19 **Wellbeing** [Please CIRCLE the number that best represents your answer]

HOW OFTEN during the PAST MONTH:	None of the time	A little of the time	Some of the time	Most of the time	All of the time
1. Did you feel tired out for no good reason?	1	2	3	4	5
2. Did you feel nervous?	1	2	3	4	5
3. Did you feel so nervous that nothing could calm you down?	1	2	3	4	5
4. Did you feel hopeless?	1	2	3	4	5
5. Did you feel restless or fidgety?	1	2	3	4	5
6. Did you feel so restless you could not sit still?	1	2	3	4	5
7. Did you feel depressed?	1	2	3	4	5
8. Did you feel that everything was an effort?	1	2	3	4	5
9. Did you feel so sad that nothing could cheer you up?	1	2	3	4	5
10. Did you feel worthless?	1	2	3	4	5

PART C asks generic questions about your background, education, diet and work. Instructions on how to answer each question are provided at beginning of each question.

20 Diet [Please WRITE an appropriate number or choose from the options provided]

A1. My usual daily serves of fruit: __________(serves) *Number*

A2. My usual daily serves of vegetables: ________(serves) *Number*

B1. Since same time last year, my fruit consumption: ☐ Increased ☐ Decreased ☐ Stayed about the same

B2. Since same time last year, my vegetable consumption: ☐ Increased ☐ Decreased ☐ Stayed about the same

C1. How often is salt used in your household for cooking or preparing food? ☐ Very often ☐ Occasionally ☐ Rarely ☐ Not used

C2. How often is salt added to food at the table? ☐ Very often ☐ Occasionally ☐ Rarely ☐ Not used

21 **General information** [Please CROSS or WRITE your answer, where required]

A. Please write your YEAR OF BIRTH ☐☐☐☐

B. Please mark your GENDER
☐ Male
☐ Female

C. In which country were you born? ☐ Australia ☐ Other country (please specify) ________________
Which year did you migrate to Australia? ☐☐☐☐

D. Are you of Aboriginal or Torres Strait Islander origin?
☐ No ☐ Yes, Torres Strait Islander
☐ Yes, Aboriginal ☐ Yes, Aboriginal & Torres Strait Islander

E. What is the main language you speak at home?
☐ English
☐ Other (please specify) ____________________

F. What is your current marital status?
☐ Single, never married ☐ Divorced
☐ Married or de facto partnership ☐ Separated
☐ Widowed

G. Do you have children?
☐ Yes
☐ No **If NO go to Question H now**

> Please provide the ages of your children starting with your oldest child (in years/months)

1.		3.		5.	
2.		4.		6.	

H. What is the HIGHEST level of education you have completed?
☐ No schooling completed ☐ Completed high school
☐ Completed primary school ☐ Vocational training
☐ Some high school ☐ University degree/Tertiary qualification

I. Where did you complete your highest education?
☐ In Australia
☐ In other country (please specify) ____________________

22 Work related information

A. Are you currently employed?
- ☐ Yes, full time
- ☐ Yes, part-time
- ☐ No, not currently working

B. Please select an option that best describes the work you do?
- ☐ Managers
- ☐ Professionals
- ☐ Technicians and trade workers
- ☐ Community and personal service workers
- ☐ Clerical and administrative workers
- ☐ Sales workers
- ☐ Machinery operators and drivers
- ☐ Labourers

C. Which of the following best describes the position you hold within your business or organisation?
- ☐ Managerial
- ☐ Supervisory
- ☐ Non-management/Non-supervisory

D1. How would you describe your management position?
- ☐ Top
- ☐ Upper
- ☐ Middle
- ☐ Lower

D2. Do you participate in making policy decisions such as products or services delivered, people employed, budgets and so forth?
- ☐ Yes
- ☐ No

D3. As an official part of your job, do you supervise the work of other employees or tell other employees what work to do?
- ☐ Yes
- ☐ No

E. How many people contribute to your household income?
- ☐ Only ME
- ☐ Myself and my PARTNER
- ☐ Myself, my partner and OTHERS (including children, parents)

F. Which category does your total household income (before tax) fall into? Include any salaries, pensions, allowances, benefits etc. from all persons in the household. (Please CROSS one box only)
- ☐ Less than $20,000
- ☐ $20,001 to $40,000
- ☐ $40,001 to $60,000
- ☐ $60,001 to $80,000
- ☐ $80,001 to $100,000
- ☐ $100,001 to $120,000
- ☐ $120,001 to $140,000
- ☐ $140,001 to $160,000
- ☐ $160,001 to $180,000
- ☐ More than $180,000

Please feel free to write here if you have any suggestions/comments:

THE UNIVERSITY of ADELAIDE

TRACK THE STUDY PROGRESS AND RESULTS BY VISITING OUR **WEBSITE**:

www.adelaide.edu.au/arcpoh/dentalcarestudy

If you would like future correspondence by email please provide us with your email address in the box below:

Appendix 3. Ethics approvals

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
RESEARCH ETHICS AND COMPLIANCE UNIT

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CRICOS Provider Number 00123M

17 November 2011

Associate Professor D Brennan
School of Dentistry

Dear Associate Professor Brennan

APPROVAL No.: **H-288-2011**
PROJECT TITLE: **Dental health services research for improved oral health outcomes**

I write to advise you that on behalf of the Human Research Ethics Committee I have approved the above project. Please refer to the enclosed endorsement sheet for further details and conditions that may be applicable to this approval.

The ethics expiry date for this project is: 30 November 2012

Participants taking part in the study are to be given a copy of the Information Sheet and the signed Consent Form to retain.

Please note that any changes to the project which might affect its continued ethical acceptability will invalidate the project's approval. In such cases an amended protocol must be submitted to the Committee for further approval.

It is a condition of approval that you **immediately report** anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants
- proposed changes in the protocol; and
- unforeseen events that might affect continued ethical acceptability of the project.

It is also a condition of approval that you inform the Committee, giving reasons, if the project is discontinued before the expected date of completion.

A reporting form is available from the website at http://www.adelaide.edu.au/ethics/human/guidelines/reporting. This may be used to renew ethical approval or report on project status including completion.

Yours sincerely

PROFESSOR GARRETT CULLITY
Convenor
Human Research Ethics Committee

THE UNIVERSITY *of* ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY

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CRICOS Provider Number 00123M

26 November 2012

Associate Professor D Brennan
School of Dentisrty, University of Adelaide

Dear Associate Professor Brennan

PROJECT NO: H-288-2011
Dental health services research for improved oral health outcomes

Thank you for your report on the above project. I write to advise you that I have endorsed renewal of ethical approval for the study on behalf of the Human Research Ethics Committee.

The expiry date for this project is: 30 November 2015

Where possible, participants taking part in the study should be given a copy of the Information Sheet and the signed Consent Form to retain.

Please note that any changes to the project which might affect its continued ethical acceptability will invalidate the project's approval. In such cases an amended protocol must be submitted to the Committee for further approval. It is a condition of approval that you immediately report anything which might warrant review of ethical approval including (a) serious or unexpected adverse effects on participants (b) proposed changes in the protocol; and (c) unforeseen events that might affect continued ethical acceptability of the project. It is also a condition of approval that you inform the Committee, giving reasons, if the project is discontinued before the expected date of completion.

A reporting form is available from the Committee's website. This may be used to renew ethical approval or report on project status including completion.

Yours sincerely

Dr John Semmler
Acting Convenor
Human Research Ethics Committee

Appendix 4. Psychometric properties of the EQ-5D-3L in South Australia: a multi-method non-preference-based validation study

This thesis also comprises an additional published article that I contributed to during my candidature as the first author. This study wasn't part of the original research questions and aims of the presented thesis. However, in this article, one of the outcome variables used in the thesis (EQ-5D-3L) was psychometrically validated for the first time in a general population sample in Australia. Also, this study used the same dataset as the present thesis (DCOHS, See 3.1.1). This study found that the EQ-5D-3L showed good psychometric properties and was able to discriminate healthy respondents from those with health problems.

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Psychometric properties of the EQ-5D-3L in South Australia: a multi-method non-preference-based validation study

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ABSTRACT

Objective: Although HRQoL tools such as the EQ-5D-3L are significant in determining health status, these measures have not been validated in general populations in Australia. This study aims to psychometrically validate the EQ-5D-3L in a large population sample in Australia for the first time.

Methods: The EQ-5D-3L was included in the Dental Care and Oral Health study (DCOHS), conducted in a South Australian population sample. The participants were 23–91 years old, and 44.1% were male. The EQ-5D-3L was responded to on a three-point rating scale ("none"/"no", "some" and "extremely"/"unable"/"confined"). We employed the area under the receiver operating characteristic curve (AUROC) to evaluate whether the EQ-5D-3L total score could identify participants with diagnosed diseases and mental health disorders. Psychometric validation of the EQ-5D-3L investigated dimensionality with Exploratory Graph Analysis, model fit, floor/ceiling effects and criterion validity.

Results: The EQ-5D-3L comprised two dimensions, Activities and Symptoms. According to Root Mean Squared Error of Approximation (RMSEA) (<.05) and Comparative Fit Index (CFI) (>.950), the 2-dimensional structure showed excellent model fit with good reliability for the Activities subscale ($\Omega c = 0.80$–95% CI [0.77, 0.83]), and poor reliability for the Symptom subscale ($\Omega c = 0.56$–95% CI [0.53, 0.58]). The EQ-5D-3L showed adequate reliability ($\Omega c = 0.70$–95% CI [0.67, 0.72]). The EQ-5D-3L showed good discrimination for diagnosed diseases (ranging from 64.3% to 86.3%). Floor/ceiling effects were observed across all items. The EQ-5D-3L total score discriminated between respondents who were experiencing health conditions (e.g. cancer, cardiovascular disease, stroke) from healthy individuals.

Discussion: Despite the ceiling effects, the EQ-5D-3L displayed good psychometric properties as an HRQoL measure and discriminated between health states in the general South Australian population. Further research should investigate the psychometric properties of the EQ-5D-5L in South Australia and whether an increased number of response categories can mitigate the observed ceiling effects.

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Introduction

Interest in measuring health outcomes from a patient perspective has increased in recent decades[1]. For this reason, various self-reported instruments have been developed and validated specifically to capture patient-reported outcomes (PROs), an umbrella term introduced by the Food and Drug Administration (FDA)[2]. These instruments, which evaluate health from a patient perspective, are named patient-reported outcome measures (PROMs). PROMs include self-report questions which evaluate how patients feel about their health, their symptoms and the effect of suggested treatments. The information obtained from PROMs can provide a better understanding of the impact and effect of health care interventions and treatments as experienced by individuals in their own lives[3]. Moreover, several important health outcomes, such as perception of pain or depression, cannot be directly measured and need to be evaluated with PROMs. For this reason, PROMs are highly informative and provide new insights into a patient's health status compared to objective health measures (e.g. blood test, waist circumference)[4].

The WHO defines health as "a state of complete physical, mental and social well-being, and not merely the absence of disease and infirmity"[5]. Quality of life has been defined as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns"[6]. While quality of life includes the effect of *all* aspects and factors that affect an individual's life, health-related quality of life (HRQoL) is focused on factors that concern individuals' health[7]. Patient self-report instruments were initially developed to measure specific health conditions (e.g. inflammatory bowel disease)[8]. However, PROMs have emerged in the last few decades as important measures of general health, including HRQoL. PROMS can be used to compare health status across

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population groups (within a country) as well as across different countries and cultures.

The most commonly applied instrument to measure HRQoL is the EQ-5D-3L[9]. The EQ-5D-3L is a generic measure developed by the EuroQol group in the 1980s to describe and value health according to five dimensions (mobility, self-care, usual activities, pain/discomfort and anxiety/depression)[10]. Items are rated on three response categories ("none"/"no", "moderate"/"some", "extreme")[11]. Over the years, the EQ-5D-3L has been extensively used worldwide in over 160 different languages and different populations[9,12]. Validation studies in multiple countries and conditions have demonstrated overall good psychometric properties[13–17]. However, the EQ-5D-3L also has limitations, most notably ceiling effects when it is used in general population surveys[9], and it has reduced sensitivity with respect to outcomes of disease-based studies[18]. These limitations led to the recent development of an alternative version, namely the EQ-5D-5L, which increased the EQ-5D-3L number of response categories from three to five[9]. Overall, using the EQ-5D-3L as a non-disease specific tool has proven important in assessing health outcomes and quality of life measures, and providing health care policies with economic value at a population level[10].

Among the EQ-5D-3L different uses, an important one is the calculation of health utilities. Health utilities are numeric values representing the strength of an individual's preference for specific health states[19]. For example, individuals might consider a health state of moderate anxiety and low chronic pain preferable to a state of low anxiety and high chronic pain. The derivation of health utilities from the EQ-5D-3L follows a two-step process. Firstly, the health states (mobility, self-care, usual activities, pain/discomfort and anxiety/depression) are measured according to item responses (1 = "none"/"no", 2 = "moderate"/"some" and 3 = "extreme"). In total, 243 possible health states are described by the combination of EQ-5D-3L three response categories and five distinct items. Secondly, these unique health states are then ranked by preference-based methods, such as standard gamble or time-trade off, to indicate which health states are more or less preferable[12]. These health states are ranked by individuals on a continuum ranging from −1 (worse than death) to 0 (indicating death) and 1 (indicating optimal health)[20]. Previous empirical research has provided several examples of health states considered by individuals as worse than death, such as traumatic brain injuries[21]. From health utility instruments, researchers can further derive outcome measures such as quality-adjusted life-years (QALYs)[22]. The successful application of preference-based methods to derive health utilities, however, is contingent upon whether the distinct health states were correctly measured.

As previously emphasized by HRQoL researchers, the first phase in the process of developing a preference-based single index measure intended to be used for the calculation of QALYs is to create a measure that is "*amenable* [emphasis added] to valuation using a preference-elicitation technique"[23]. In other words, the application of non-preference based psychometric methods is necessary to ensure that the EQ-5D-3L correctly measures the health states of mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Once the EQ-5D-3L validity is established, then preference-based methods can be applied to rank the health states and the health utilities for a specific population derived.

In Australia, EQ-5D-3L health utilities were derived for the general Australian population using the time trade-off elicitation method[24,25] and later were found to perform as well as utilities originally derived in the USA and UK[26]. For the EQ-5D-5L, population norms based on health utilities have also been derived for specific Australian states, such as South Australia[27]. There is, however, one research gap that the current study aims to address. To the best of our knowledge, no previous study has evaluated the EQ-5D-3L psychometric properties using non-preference-based methods in any Australian population. Given that differences in other health measures, including disease-specific measures such as the 14-item Perceived Stress Scale (PSS-14), were found in an Australian population compared to other countries[28], it is necessary to ensure that the EQ-5D-3L is correctly measuring the health states of mobility, self-care, usual activities, pain/discomfort and anxiety/depression in Australian populations. Establishing the EQ-5D-3L validity is a prerequisite for researchers to be confident of deriving or employing Australian national and state-level health utilities and establishing population norms.

The present research

In this study, we will evaluate the psychometric properties of the EQ-5D-3L in the state of South Australia. Participants comprised a large population-based sample from the Dental Care and Oral Health Study (DCOHS), a cohort study designed to observe the influence of different pathways of dental services utilization (public/private) and changes in oral health outcomes over a period. To examine the psychometric properties of the EQ-5D-3L, we followed the steps recommended by Young et al.[23]: (1) evaluation of the dimensionality of the instrument; and (2) evaluation of performance at the item level, such as examination of floor/ceiling effects and (3) criterion validity. Regarding the first step, the instrument dimensionality refers to how the items cohere together, representing dimensions of the construct being measured (i.e. dimensions of HRQoL) [29]. Elucidating the EQ-5D-3L dimensionality will inform how many subscale scores should be calculated (i.e. one subscale score for each dimension), providing valuable information for researchers who, instead of examining the 243 possible health states, want to investigate broader dimensions of HRQoL. The second step will investigate whether the three EQ-5D-3L response categories are adequate and examine floor/ceiling effects. Floor and ceiling effects refer to the proportion of individuals scoring on the lowest or highest response category, respectively[29]. Floor effects suggest an inability of the scale to discriminate individuals with low levels of the construct (i.e. low HRQoL) since these individuals would endorse categories indicating even worse levels of the construct in case these were available[30]. Similarly, ceiling effects can suggest the instrument's inability to discriminate individuals with high construct levels (i.e. high HRQoL). The third step will investigate whether the EQ-5D-3L scores are sensitive to capture individuals experiencing worse HRQoL due to health conditions, such as cancer, cardiovascular disease or stroke. In summary, our study intends to evaluate the EQ-5D-3L psychometric properties to inform how the instrument can be used in future research in South Australia and Australia.

Participants

Data were collected as a part of the DCOHS. The DCOHS is a cohort study aimed at recording the changes in oral health outcomes according to different pathways of dental services utilisation and included adults residing in South Australia randomly sampled from the Electoral Roll. Data were collected by self-completed questionnaire. The data collected information on oral health and general health, health-related behaviours, demographics and socioeconomic variables (age, sex, place of birth, education, occupation, income, financial strain), and psychosocial variables. The DCOHS was funded by an NHMRC grant (1031310). Participation in the study was voluntary and confidential. Ethics approval was obtained from the University of Adelaide Human Research Ethics Committee (H-288-2011)[31].

Primary measure

EQ-5D-3L: The EQ-5D-3L is an instrument for evaluating health-related quality of life under five dimensions; Mobility, Self-Care, Usual Activities, Pain/Discomfort and Anxiety/Depression. The responses were collected at a 3-level response scale ("1 = None/No", "2 = Moderate/Some" and "3 = Severe/Extreme")[32]. Respondents who did not provide answers to each of the five items of the EQ-5D-3L questions were considered missing responses. The higher EQ-5D-3L total scores represent poorer HRQoL.

Secondary measures

The K-10 instrument, measures of self-rated general health and chronic conditions were selected to evaluate the EQ-5D-3L criterion validity.

K-10

K-10 is a 10-question based instrument, which assesses mental health by evaluating the emotional state on a 5-level response scale (1 for "None of the time" to 5 for "All the time"). It helps in identifying distress levels[33]. The K-10 total scores (minimum 10 to maximum 50) were categorised into four levels based on the Australian psychological distress standard score groupings and categories derived from combined work of the Clinical Research Unit for Anxiety and Depression (CRUfAD) and other researchers (Low/Moderate/High/Very High)[34]. We created a dichotomous variable distinguishing between Low and Moderate/High/Very High psychological distress.

Self-rated general health

Self-rated general health was measured using the single-question global rating "How would you rate your general health?" with response categories of "Excellent", "Very good", "Good", "Poor" and "Very Poor". The measure of self-rated general health was dichotomised so the categories "Good" to "Excellent" indicated good general health, and the categories "Very Poor" to "Poor" indicated poor health[35].

Chronic medical conditions

The chronic medical conditions were evaluated with the question "Do you have any of these chronic medical conditions?". Participants could choose from the options listed in the questionnaire to indicate which chronic medical conditions they suffer from (such as arthritis, cancer, depression, epilepsy, hip fracture, osteoporosis, cardiovascular disease, stroke, diabetes and Parkinson's disease). The responses were coded as "Yes" (for the participants suffering from that chronic medical condition) and "No" (for those who did not select, showing the respondents did not suffer from that chronic medical condition).

Statistical analysis

Population norms of the EQ-5D-3L (score distribution)

Following previous studies[36,37], to inform population norms of the EQ-5D-3L in South Australia, we report items and total score mean and standard deviations according to the general population, sex and age distribution. Furthermore, we also dichotomised the EQ-5D-3L item responses according to any problems ("Moderate/Some" and "Severe/Extreme") or no problems ("None/No"). We report the proportions of any problems according to the general population, sex and age distribution[36,37].

Data splitting

To avoid overfitting, we used a data-splitting procedure to divide the sample into development and validation samples. Overfitting is the use of incorrect statistical models[38] due to mistakenly fitting patterns in the data that are specific to a certain sample (but not the population)[39]. That is, the statistical model fits data patterns (such as outliers) that occur by chance in a specific sample. Consequently, the model does not generalise and has poor predictive performance among other samples from the same population. Overfitting is a concern, for example, when evaluating whether the identified dimensions of an instrument (e.g. EQ-5D-3L dimensionality) can adequately explain the (covariance of) item responses (i.e. model fit). The identified dimensions should explain item responses on *new* samples from the population, and not only on the *same* sample the dimensions were identified. When research findings only indicate that the identified dimensions explain the item responses on the *same* sample, there is no guarantee that these dimensions will generalise to new samples and represent the true number of dimensions in the population[40]. Ideally, to avoid overfitting, the researchers would have access to another sample from the same population. However, one possible methodological solution is data splitting due to limitations in conducting large population studies (such as the DCOHS) more than once.

Data splitting refers to dividing the sample into the development and validation samples. The development sample is the sample used to *estimate* the model (i.e. used to identify the number of dimensions). In contrast, the validation sample is used to *evaluate* the model (i.e. evaluation of model fit)[41]. In our study, we used a data-splitting procedure[42] in which the complete cases sample ($n = 4333$) was randomly divided into development sample ($n = 1299$) and validation sample ($n = 3034$). As a recommended practice in data splitting[43], we used a data split ratio of 3:7, so the development sample included 30% of the participants, while the validation sample included 70% of the participants.

Dimensionality

Dimensionality refers to how the items of a questionnaire cluster together and thereby represent one or more dimensions of the measured construct[29,44]. A state-of-the-art method, namely Exploratory Graph Analysis (EGA) [45], was used to investigate the dimensionality of EQ-5D-3L. EGA is part of the new field of network psychometrics. In a psychometric network, items are represented by nodes, and the associations between items, usually characterised by partial correlations, are represented by edges[46]. EGA employs a community-detection algorithm, namely the Louvain algorithm[47], to identify *clusters* of items. Item clustering occurs when certain items are more strongly associated than the other items in the rest of the network[48]. To estimate the network, we used the Gaussian Graphical Model (GGM)[49] with the Graphical LASSO (GLASSO)[50]. The selection of the GLASSO turning parameter was based on minimizing the Extended Bayesian Information Criteria (EBIC)[51]. Considering that the EQ-5D-3L polytomous items were not normally distributed (they are, by definition, ordinal), polychoric correlations were used as input[52].

For the EGA, the Louvain algorithm was chosen since a recent simulation study showed this to be among the most accurate algorithms, performing better than state-of-the-art factor analytical approaches, such as parallel analysis, to identify dimensionality[48]. To ensure the robustness of the EGA-identified dimensions to sampling variation, we investigated the dimensionality across 2500 bootstrap samples to inform the most frequent dimensional structure discovered by the Louvain algorithm[53]. The network was plotted with the Fruchterman-Reingold algorithm[54], which arranges nodes more closely according to the strength of their associations. The final network plot has nodes representing the five EQ-5D-3L items, and the nodes were coloured according to the dimensions identified by EGA. The identification of dimensionality was conducted on the development sample. The statistical analysis was performed with the free, open-source software R and specifically the R package *EGAnet*[53].

Model fit

The EGA initially identified the EQ-5D-3L dimensionality in the *development* sample and then we evaluated the fit of the proposed dimensionality in the *validation* sample through Confirmatory Factor Analysis (CFA). The EGA identified dimensionality was compared with the unidimensional model. The unidimensional model is the most parsimonious, so more complex dimensional structures (e.g. two dimensions, three dimensions) need to be a better fit than the unidimensional model[55]. CFA models were estimated with weighted least squares with a mean- and variance-adjusted (WLSMV) test statistic[56]. Model fit was evaluated with the χ^2, RMSEA and CFI. Values of CFI $\geq$0.96 and RMSEA $\leq$0.05 indicate a good model fit, while RMSEA $\leq$0.07 indicates an acceptable fit[57]. Reliability was evaluated with the internal consistency reliability coefficient McDonald's Omega[58]. The advantage of the Omega coefficient over other internal consistency reliability coefficients more commonly utilised (e.g. Cronbach's α) is that it does not require strong assumptions such as tau-equivalence, which are rarely achieved by questionnaires in health science[59]. We also examined corrected item-total correlations (CITCs)[60]. The CITC indicates the degree that responses to an individual item are consistent with the instrument corrected total score (i.e. the total score minus the item score). A high CITC indicates that the item is consistent with the instrument as a whole, which is a desirable psychometric property for each individual item[29]. Due to the ordinal nature of EQ-5D-3L items, CITCs were calculated with non-parametric correlation Kendall's τ. The model fit in factor models was evaluated with R package *lavaan*[61]. Model fit and all subsequent analyses were conducted on the validation sample, including the examination of floor/ceiling effects and criterion validity.

Floor/ceiling effects

To investigate floor and ceiling effects, we considered the percentage of participants who scored at the lowest or highest response category, respectively[62]. Since it is expected that a third of participants (33%) would endorse the lowest or highest response category by chance alone, we considered floor or ceiling effects when more than an additional 15% of participants (>48%) endorsed these categories[63].

Criterion validity

We investigated the AUROC[64] to evaluate whether EQ-5D-3L total score could identify participants with diagnosed diseases and mental health disorders. The AUROC is a measure that indicates the probability that an individual with poor general health (or with a chronic condition) randomly chosen can be correctly classified (as having poor general health) based on EQ-5D-3L scores compared to another randomly chosen individual with good general health (or without a chronic condition). To indicate good criterion validity, the AUROC needs to be at least higher than 50% since values higher than 50% indicate the EQ-5D-3L total score correctly classified participants with poor general health, diseases and mental health disorders better than random chance (50% probability). For interpretation guidelines, AUROC between 0.5 and 0.7 is considered low, AUROC between 0.7 and 0.9 is considered moderate, and AUROC above 0.9 is considered high[65]. The diagnosed diseases and mental health disorders evaluated were arthritis, cancer, depression, epilepsy, hip fracture, osteoporosis, Parkinson's disease, cardiovascular disease, stroke and diabetes. We also evaluated whether the EQ-5D-3L total score could classify participants according to their general health (poor/good) and psychological distress (low/high).

Results

A total of 12,245 adults aged 18 years or over were randomly sampled from the Electoral Roll of South Australia and received invitations to participate in the study by mail (with up to three follow-up mailings). In total, 4494 valid responses were received, representing a response rate of 44.8% (after adjusting for out of scope samples such as change of address or those who never received the questionnaire). The sample comprised a comprehensive and diverse population of South Australia. Considering that missing responses on individual EQ-5D-5L items were unsubstantial (ranging from 1.9% on the item mobility to 2.1% on the item anxiety/depression), multiple imputation was not required[66], and all analyses were conducted on a complete cases sample (i.e. complete responses to all items) ($n = 4333$). The respondents' sociodemographic characteristics are shown in Table 1.

The majority of participants had education above high school (53%) and did not have access to a health care card (72.3%). The average age was 58.4 years, and approximately 52% were in the 60 years or more age group. More than half (55.9%) of the participants were female. The median age of the respondents was 60.0 years. Approximately 75% resided in metropolitan locations (Greater Adelaide). The prevalence of self-rated general health, chronic medical conditions and psychological distress are presented in Table 2. The majority of respondents rated their general health as good (94%), and the highest prevalence of the participants had no chronic medical conditions. Around one-fifth (20.4%) of the participants had arthritis. The prevalence of other chronic medical conditions such as Parkinson's disease (0.4%), epilepsy (0.6%), hip fracture (0.8%), cancer (3.1%), osteoporosis (4.9%), cardiovascular disease (7.5%), stroke (2.0%), diabetes (8.1%) and depression (7.6%) was relatively low. Also, almost half (45.4%) of the participants reported high psychological distress.

The population norms of the EQ-5D-3L items and total score in the South Australia population are displayed in Table 3. The reported problems (% of any problems) on the EQ-5D-3L items are displayed in Figure 1.

Dimensionality

The EQ-5D-3L had a two-dimensional structure as identified by EGA. The first dimension was interpreted as the "Activities" dimension, comprising the items "Mobility", "Self-care" and "Usual activities". The second dimension was interpreted as the "Symptoms" dimension, comprising the items "Anxiety/Depression" and "Pain". The EQ-5D-3L network is shown in Figure 2, and the network edges are displayed in Table 4.

We applied EGA to the 2500 bootstrap samples. In 99% of the bootstrap samples, EGA identified 2-dimensional structures. Unidimensional structures were identified in the other 1% of the bootstrap samples. These results indicate that the 2-dimensional structure was robust to sampling variation and was stable across the bootstrap samples.

Model fit

The next step was to compare the fit of the EGA-identified 2-dimensional structure (identified in the development sample) with the unidimensional structure in the validation sample. Table 5 indicates that, although the fit of the unidimensional structure was good, the fit of the 2-dimensional structure was excellent since RMSEA (<.05) and CFI (>.950). Reliability of the Activities subscale was good (Ω_c = 0.80–95% CI [0.77, 0.83]), while reliability of the Symptoms subscale was poor (Ω_c = 0.56–95% CI [0.53, 0.58]). Reliability of the EQ-5D-3L was adequate (Ω_c = 0.70–95% CI [0.67, 0.72]). The items mobility ($\tau = 0.46$–95% CI [0.44, 0.47]), self-care ($\tau = 0.26$–95% CI [0.25, 0.27]), usual activities ($\tau = 0.48$–95% CI [0.46, 0.50]), pain/discomfort ($\tau = 0.46$–95% CI [0.44, 0.48]) and anxiety/depression ($\tau = 0.26$–95% CI [0.24, 0.28]) displayed moderate to strong CITC.

Table 1. Characteristics of study participants.

	Original sample ($n = 4494$)		Complete case sample ($n = 4333$)	
	n	%	n	%
Age mean (SD)	58.8 (16.13)		58.4 (16.03)	
<35 years old	451 (M[a] = 161, F[b] = 290)	10.0	440 (M = 156, F = 284)	10.2
35–44 years old	459 (M = 180, F = 315)	11.0	489 (M = 178, F = 311)	11.3
45–59 years old	1198 (M = 518, F = 680)	26.7	1170 (M = 505, F = 665)	27.0
60–70 years old	1128 (M = 516, F = 612)	25.1	1093 (M = 503, F = 590)	25.2
>71 years old	1222 (M = 601, F = 621)	27.2	1141 (M = 567, F = 574)	26.3
Sex				
Male	1976	44.0	1909	44.1
Female	2518	56.0	2424	55.9
Location				
Greater Adelaide	3373	75.1	3249	75.0
Rest of South Australia	1121	24.9	1084	25.0
Education				
Up to high school	2071	46.0	1974	45.6
Above high school	2330	51.9	2297	53.0
Missing	93	2.1	62	1.4
Access to health care card				
Yes	855	19.0	814	18.8
No	3225	71.8	3134	72.3
Not stated/Not known	414	9.2	385	8.9

[a]M: Male; [b]F: Female.

Floor/ceiling effects

Strong ceiling effects (i.e. individuals with high HRQoL) were identified across all items since the percentages of participants that endorsed the lowest response category on the items mobility (86%), self-care (97%), usual activities (87%), pain/discomfort (60%) and anxiety/depression (73%) were above 48%. In addition, 48% of the respondents endorsed the 'none/no problem' category across all items.

Criterion validity

The AUROCs higher than 70% indicated that EQ-5D-3L total score moderately discriminated participants diagnosed with diseases and mental health disorders, with the exception of Epilepsy, Cardiovascular disease, Diabetes and Cancer (which had AUROCs between 64% and 69%) (Figure 3). For example, as illustrated in Figure 3, the probability of identifying a participant with poor general health through high EQ-5D-3L total scores was 86.3% higher than if the participant had good general health (first row, first column). These findings suggest good concurrent validity of the EQ-5D-3L total score.

Table 2. Prevalence of study participants for self-rated general health, chronic medical conditions and psychological distress.

	Complete case sample	
	n	%
Self-rated general health ($n = 4282$)		
Good health[a]	4025	94.0
Poor health[b]	257	6.0
Arthritis ($n = 4333$)		
No	3447	79.6
Yes	886	20.4
Cancer ($n = 4333$)		
No	4200	96.9
Yes	133	3.1
Depression ($n = 4333$)		
No	4004	92.4
Yes	329	7.6
Epilepsy ($n = 4333$)		
No	4305	99.4
Yes	28	0.6
Hip fracture ($n = 4333$)		
No	4298	99.2
Yes	35	0.8
Osteoporosis ($n = 4333$)		
No	4120	95.1
Yes	213	4.9
Parkinson's disease ($n = 4333$)		
No	4317	99.6
Yes	16	0.4
Cardiovascular disease ($n = 4333$)		
No	4009	92.5
Yes	324	7.5
Stroke ($n = 4333$)		
No	4248	98.0
Yes	85	2.0
Diabetes ($n = 4333$)		
No	3982	91.9
Yes	351	8.1
Psychological distress (K-10) ($n = 4211$)		
Low	2300	54.6
Moderate/High/Very high	1911	45.4

[a]Good to excellent; [b]Very poor to poor [35].

Discussion

This study aimed to validate the psychometric properties of the EQ-5D-3L in a South Australian population. The EQ-5D-3L, as an HRQoL instrument, presented good psychometric properties and effectively discriminated between different health conditions in the general South Australian population (regardless of the ceiling effects).

In our study, we identified two dimensions: Symptoms and Activities. These two broad dimensions encompass the five aspects of HRQoL measured by the EQ-5D-3L, since the Symptoms dimension includes pain/discomfort and anxiety/depression, while the Activities dimension includes mobility, self-care and usual activities. These dimensions have been identified in the conceptual model developed by Wilson and Cleary, which proposes direct causal relationships between physiological variables, symptoms, physical functional status, perceptions of general health, and HRQoL[67,68]. The conceptual model developed by Wilson and Cleary proposed theoretical dimensions related to HRQoL and can be used to elucidate the empirical dimensions identified in instruments such as the EQ-5D-3L but also other HRQoL instruments. Wilson and Cleary used Symptoms to refer to psychophysical symptoms (pain, depression and anxiety) and Activities to refer to physical functioning (mobility, usual activities and self-care). The relationship between these two dimensions was defined as being complex[67,68]. For example, a person with a broken arm would experience the Symptoms like pain before the Activities, such as limited functionality/usual activities and incapability of self-care. Another example is depression. The patient who suffers from depression (with many Symptoms) would have limited Activities (such as lower self-care and limited usual activities), while no physiological symptoms could be clinically recognisable.

These two dimensions (Symptoms and Activities) were also identified in studies that evaluated the EQ-5D-5L. For

Table 3. EQ-5D-3L item and total scores according to the general population, sex and age group.

	Mobility	Self-care	Usual activities	Pain/Discomfort	Anxiety/Depression	EQ-5D-3L Total score
General population	1.14 (0.35)	1.03 (0.17)	1.14 (0.36)	1.42 (0.55)	1.29 (0.51)	6.02 (1.36)
Sex						
Male	1.14 (0.35)	1.03 (0.19)	1.14 (0.37)	1.42 (0.55)	1.26 (0.48)	5.99 (1.36)
Female	1.13 (0.34)	1.02 (0.16)	1.14 (0.36)	1.43 (0.55)	1.32 (0.54)	6.04 (1.36)
Age						
<35 years old	1.03 (0.19)	1.01 (0.09)	1.06 (0.24)	1.18 (0.39)	1.36 (0.56)	5.63 (1.02)
35–44 years old	1.06 (0.25)	1.01 (0.13)	1.08 (0.29)	1.28 (0.49)	1.29 (0.51)	5.72 (1.18)
45–59 years old	1.11 (0.32)	1.02 (0.16)	1.13 (0.37)	1.43 (0.56)	1.31 (0.52)	6.00 (1.37)
60–70 years old	1.19 (0.39)	1.03 (0.19)	1.16 (0.38)	1.54 (0.57)	1.28 (0.50)	6.19 (1.45)
>71 years old	1.28 (0.45)	1.06 (0.25)	1.25 (0.45)	1.60 (0.56)	1.22 (0.45)	6.41 (1.48)

Note. Mean and standard deviations (SDs) are reported (Mean (SD)).

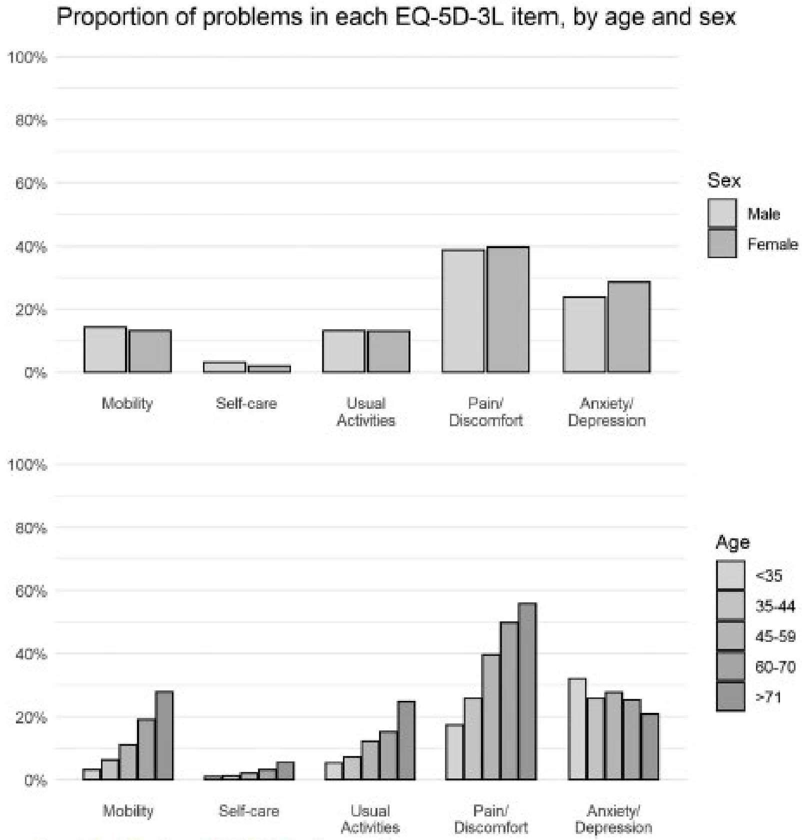

Figure 1. Percentage of reported problems for each EQ-5D-3L item, by age and sex.

instance, Santiago reported that the same dimensions were found in the EQ-5D-5L in an Aboriginal Australian population[69]. Considering that the number of response categories can influence the estimated number of dimensions[70,71], that the same dimensionality was observed across the EQ-5D-3L (three response categories) and EQ-5D-5L (five response categories) provides further evidence that the Symptoms and Activities dimensions were substantive (instead of spurious dimensions due to the number of response categories). The evidence that the five EQ-5D-3L (or EQ-5D-5L) items cluster into two broader dimensions of HRQoL does not implicate any practical or theoretical problems for future applications of the instrument. The evidence regarding two dimensions just indicates that the items can usually be assessed individually (items scores to evaluate mobility, self-care, usual activities, pain/discomfort and anxiety/depression) or combined (subscale scores to evaluate these two broader dimensions of HRQoL). However, we advise against calculating subscale scores for the Symptoms dimension since this dimension displayed poor internal consistency reliability and did not achieve the minimum reliability values (>.70) considered adequate for research purposes. We recommend that only total scores (i.e. summing across all EQ-5D-3L items) and/or Activities dimension subscale scores should be employed in future applications of the EQ-5D-3L in South Australia. The EQ-5D-3L items also displayed good CITC, indicating that each of the five individual items (mobility, self-care, usual activities, pain/discomfort and anxiety/depression) were consistent with the EQ-5D-3L as an overall measure of HRQoL.

In addition, our study identified strong ceiling effects across all EQ-5D-3L items. Ceiling effects occur in the EQ-5D-3L when there are high proportions of answers to the "none/no problem" category (due to many individuals with high HRQoL). The strong EQ-5D-3L ceiling effects observed in our study are consistent with previous studies that reported ceiling effects in other populations[72–76]. Previous studies have also reported floor effects in the EQ-5D-3L[77–85]. Floor effects occur when there are high proportions of answers to the "extreme problem" category and were mostly identified in other studies when the EQ-5D-3L was applied to patients with acute or severe health conditions, such as patients with disabilities, with HIV/AIDS or in postoperative care[77–85]. One

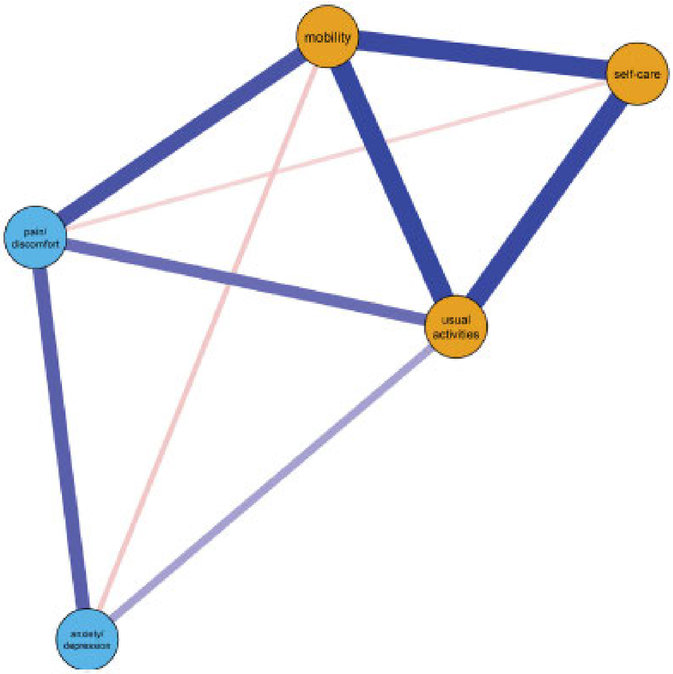

Figure 2. Network of the EQ-5D-3L. Nodes represent items and edges represent partial correlation coefficients. The "Activities" dimension is represented by orange nodes, while the "Symptoms" dimension is represented by blue nodes. Positive partial correlations (edges) are displayed as blue lines and negative partial correlations (edges) are displayed as red lines.

Table 4. Network edges of the EQ-5D-3L.

	Mobility	Self-care	Usual activities	Pain/Discomfort	Anxiety/Depression
Mobility	1.00				
Self-care	0.40	1.00			
Usual activities	0.42	0.40	1.00		
Pain/Discomfort	0.32	−0.07	0.24	1.00	
Anxiety/Depression	−0.09	0.00	0.15	0.28	1.00

Note. Network edges are regularised partial correlations and indicate the structure of conditional dependence between variables (nodes) in the network.

Table 5. Model fit comparison of 1- and 2-dimensional EQ-5D-3L structures.

Model	χ^2	*df*	*p*-Value	RMSEA	90% CI	CFI
EQ-5D-3L						
1-Dimensional structure	39.770	5	<.001	0.048	[0.035, 0.062]	0.997
2-Dimensional structure	22.828	4	<.001	0.039	[0.025, 0.056]	0.998

Note. χ^2: scaled chi-square; df: degrees of freedom; RMSEA: scaled root mean square error of approximation; CFI: scaled comparative fit index.

potential explanation for the observed ceiling effects (instead of floor effects) is that our study was conducted in a sample of the general South Australian population, in which the majority of respondents were healthy and had no severe health conditions. Since most participants had good general health, they answered "none/no problem" to most of the EQ-5D-3L items (from 60% to pain/discomfort item to 97% to self-care item). Furthermore, nearly half of respondents (48%) rated "none/no problem" across all items.

To remediate ceiling or floor effects commonly observed in the EQ-5D-3L, the EuroQol group developed a version with two additional response categories (slight and severe problems), the EQ-5D-5L. The EQ-5D-5L gave respondents more options to rate their health status, and the following studies showed that it increases the instrument discrimination, consequently reducing ceiling and floor effects[83]. Since the introduction of the EQ-5D-5L in 2011, many studies focused specifically on comparing the EQ-5D-5L and EQ-5D-3L measurement properties[72,73,77–79,86–91]. Mainly these studies reported better or leastwise similar measurement properties of EQ-5D-5L compared to the previous version EQ-5D-3L. For example, Kim et al.[92] validated the EQ-5D-5L in a general South Korean population. The study showed that the EQ-5D-5L displayed weaker ceiling effects compared to the EQ-5D-3L (i.e. 65.7% of the participants responded "none/no problem" to all items compared to

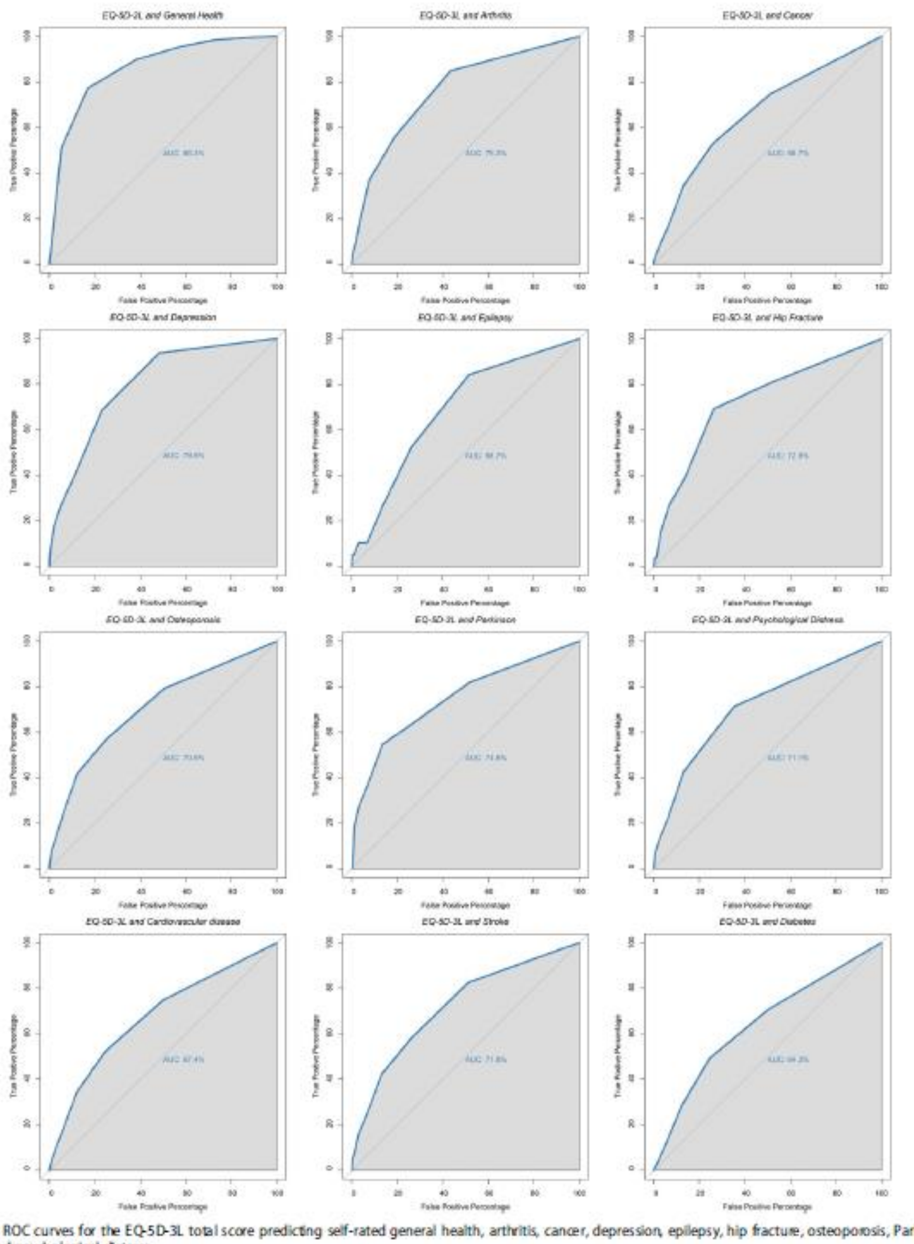

Figure 3. ROC curves for the EQ-5D-3L total score predicting self-rated general health, arthritis, cancer, depression, epilepsy, hip fracture, osteoporosis, Parkinson's disease and psychological distress.

61.2%, respectively), although the difference was small. While the EQ-5D-5L seems to have improved the instrument discrimination compared with the EQ-5D-3L in other populations, floor and ceiling effects on the EQ-5D-5L were still reported by several researchers[92,93]. Future research in Australia should use non-preference-based methods to additionally evaluate the EQ-5D-5L psychometric properties, focusing specifically on investigating floor/ceiling effects. In the event that future research using non-preference-based methods identifies that the EQ-5D-5L has better psychometric properties (such as weaker floor/ceiling effects and better discrimination) compared to the EQ-5D-3L, the application of the EQ-5D-5L will be recommended.

Regarding the EQ-5D-3L, in our study, the presence of ceiling effects did not prevent the EQ-5D-3L three response categories to discriminate between healthy participants and patients with health conditions associated with poor HRQoL such as arthritis and cancer. Despite the majority of participants being healthy and without health conditions, the large sample size of the DCOHS included a substantive number of participants with each chronic condition, including low-prevalence conditions such as osteoporosis and Parkinson's disease. For example, the DCOHS sample included 213 participants with osteoporosis (4.9%), comparable to the prevalence of osteoporosis in the general Australian population (3.8%)[94]. The recruitment of a substantive number of patients with each chronic condition was important so the EQ-5D-3L scores could distinguish them from healthy participants. For instance, we demonstrated that patients with cancer and arthritis, respectively 66.7% and 76.3% of the time, had a higher score on the EQ-5D-3L, reflecting worse health status than the respondents without cancer or arthritis. In summary, despite limitations in terms of ceiling effects and the potential for improvement with the inclusion or more response categories, the EQ-5D-3L showed the expected discriminant validity to distinguish respondents experiencing poor HRQoL due to various health conditions.

Our study is the first to examine the reliability and validity of the EQ-5D-3L instrument to measure HRQoL in the general South Australian population. The strengths include employing a multi-method approach, using cutting-edge psychometric techniques such as EGA to evaluate the EQ-5D-3L psychometric properties. Another strength was the large sample, which contained a substantive number of participants with each chronic medical condition (e.g. osteoporosis and Parkinson's disease) used to evaluate discriminant validity. The study also had limitations. For instance, although the low response rate (44.8%) is consistent with average survey response rates (below 50% for over three decades)[95], there is the possibility of response bias. Response bias is defined as the difference between the answers from respondents and non-respondents[96]. It is possible that the participants who decided to not participate were not missed completely at random (MCAR) and were different from those who participated in the DCOHS. This can lead to response bias (and biased EQ-5D-3L mean scores), with individuals who did not participate potentially having worse (or better) HRQoL than those who participated. However, the unweighted DCOHS response sample has been shown to be broadly representative of the age and sex distribution of the South Australian population, as it was drawn from the Electoral Roll, which provides a comprehensive sampling frame. Also, recent comparisons against population data confirmed the representativeness of DCOHS[31,97]. Further, as shown in Table 1, the complete case sample ($n = 4333$) was highly representative of the DCOHS ($n = 4494$). We also compared the sex and age of South Australia's population with the population census data of Australian Bureau of Statistics reports. South Australians showed a similar composition compared to Australia, with only slight differences (a little older and a slightly lower sex ratio). Furthermore, while representativeness is desirable for descriptive epidemiological studies (for instance, to calculate the prevalence of diseases in a population), a non-representative sample does not necessarily implicate that the item parameters in a validation study are biased[98] or limits the generalizability of the findings[99]. Another limitation is that, while we evaluated some of the most prevalent chronic conditions experienced by the general Australian population, including arthritis (17.8%), depression (13.7%) and diabetes (8.3%), not all high-prevalence chronic conditions could be included, such as hyperlipidaemia (18.5%) and gastro-oesophageal reflux disease (11.6%)[100]. Future studies should also evaluate whether the EQ-5D-3L discriminates respondents with poor HRQoL due to additional conditions.

Conclusion

Our study indicated good psychometric properties of the EQ-5D-3L in a general South Australian population. Scores can be used as total scores or subscale scores for the Activities scale. Despite the presence of ceiling effects, the EQ-5D-3L showed good discriminant validity and adequately identified participants suffering from a variety of conditions. The EQ-5D-3L can be used in the future by government and research, while the preference-based methods can also be used to derive population-specific health utilities.

Transparency

Declaration of funding

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Declaration of financial/other relationships

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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Author contributions

MZ and PHRS conceived the idea. MZ developed the study and wrote the manuscript, and SS and PHRS participated in completing the manuscript. PHRS conducted the psychometric analysis and validation. DB and LJ supervised the development of work. DH, DB and LJ critically reviewed the manuscript and provided intellectual contribution to the analysis. All authors read and approved the final version of the manuscript.

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Data availability statement

The dataset that generated and/or analysed during this study are available on reasonable request from the corresponding author. The dataset is not publicly available due to privacy or ethical restrictions.

Ethics approval

Ethics approval was obtained from the University of Adelaide Human Research Ethics Committee (H-288-2011). The participants' information for this study remained confidential. Also, the participant's identity was protected through the reporting of results in aggregate form.

Participating in this study was voluntary and confidential, and participants gave consent for publication through the questionnaire.

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