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Measuring socioeconomic position in studies of health inequalities

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In February 2019, I embarked on this PhD project after much consideration (I could still hear myself: 'I'm never taking a PhD!'). But there was something about the project's topic that made me reconsider this stance. Social inequalities in health in health seemed to be the ideal project. I could use my (relatively short) background in global health and inequalities on an international scale in a Norwegian context. I have enjoyed it a lot, although it has been challenging at times. One of them has been the feeling that I do not belong in one specific academic discipline. While I have been heavily influenced by epidemiologists at the ISM, I have also been trying to bring the health economist in me along the way. There is a lot of talk about the need for interdisciplinarity in research, but it is not always easy to find one's place in the intersection of several disciplines.

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Summary

There is a consistent finding across institutional contexts, populations, and health outcomes that the higher the socioeconomic position (SEP), the better the health. The choice of indicator proxying the socioeconomic dimensions of health is crucial in explaining these socioeconomic inequalities. However, a poorly motivated use of SEP indicators often prevails in the literature on social health inequalities, which hampers the transparency and comparability across studies. This thesis applies different approaches to the measurement of SEP in studying inequalities in health. Its overarching aims are to explore different ways of measuring social position to identify social inequalities in health, and to assess the added impact of lifestyles. The focus will be on the three most common, objective SEP indicators (education, occupation, and income); subjective SEP; and childhood circumstances.

This thesis consists of three papers. Papers I and III apply data from the Tromsø Study, and Paper II is based on an online panel survey investigating people's views on SEP, conducted in Norway and Australia. All three papers explore the use of different SEP indicators in the context of health inequalities. Paper I investigates the potential to combine education and income into a composite score for SEP and how it predicts inequalities in health-related quality of life (HRQoL). Paper II assesses the relative importance of objective SEP indicators and childhood circumstances in estimating subjective SEP. Paper III explores the role of (childhood) circumstances on the one hand, and that of lifestyle factors on the other, in estimating inequalities in HRQoL and self-rated health, both cross-sectionally and longitudinally.

While we found that the combination of education and income demonstrated a non-linear relationship with overall SEP, the composite SEP score was not superior as a predictor of HRQoL compared to including education and income separately. Furthermore, we found that childhood circumstances demonstrated a lasting impact on subjective SEP, independently of objective SEP indicators. Paper III revealed that there were inequalities arising from circumstances, with substantial contributions from financial circumstances in childhood and education.

This thesis demonstrates the need to carefully consider and motivate the choice of SEP indicator in studies of health inequalities. It also stresses the importance of early-life factors as determinants of health outcomes in adulthood, advocating for policies targeting childhood circumstances in equalising early life chances.

Sammendrag

Et svært vanlig funn på tvers av land, studiepopulasjoner og helseutfall er at desto høyere sosioøkonomisk posisjon (SEP), desto bedre helse. Valg av SEP-indikator som skal reflektere de sosioøkonomiske dimensjonene i helse er avgjørende for å forklare disse helseulikhetene. Likevel er det slik at bruken av SEP-indikatorer i studier om sosial ulikhet i helse ofte preges av svak eller ingen begrunnelse med utgangspunkt i teori og hypoteser, noe som begrenser muligheten til sammenligning mellom studier. Denne avhandlingen bruker ulike tilnærminger for å måle SEP i studier av helseulikhet. Et overordnet formål er å utforske ulike måter å måle sosial posisjon for å identifisere sosiale ulikhet i helse, og hvordan livsstilsfaktorer i tillegg påvirker dette forholdet. Fokuset vil være på de tre vanligste objektive SEP-indikatorene (utdanning, yrke og inntekt); subjektiv SEP; og indikatorer for barndomsforhold.

Avhandlingen består av tre artikler. Artikkel I og III er basert på data fra Tromsøundersøkelsen, mens Artikkel II benytter data fra på en nettbasert spørreundersøkelse om folks betraktninger omkring SEP, som har blitt gjennomført i Norge og Australia. Alle de tre artiklene utforsker bruken av ulike SEP-indikatorer i en helseulikhetssammenheng. Artikkel I undersøker potensialet for å kombinere utdanning og inntekt til en samleindikator for SEP, samt hvordan denne samleindikatoren predikerer helse-relatert livskvalitet (HRQoL). Artikkel II måler objektive SEP-indikatorer (utdanning, yrke og inntekt) og barndomsforholds relative betydning i å estimere subjektiv SEP. Artikkel III utforsker hvordan variabler om barndomsforhold på den ene siden og livsstilsfaktorer på den andre estimerer HRQoL og selvrapportert helse, både på et bestemt tidspunkt og over tid.

Vi fant at kombinasjonen av utdanning og inntekt viste en sterk ikke-lineær sammenheng med total SEP, mens samleindikatoren for SEP viste seg å ikke være bedre i å predikere HRQoL sammenlignet med å inkludere utdanning og inntekt separat. Videre fant vi at barndomsforhold så ut til å ha en vedvarende påvirkning på subjektiv SEP, som var uavhengig av objektiv SEP. Artikkel III viste at det var ulikheter i helse med røtter i barndomsforhold, med særlig påvirkning fra økonomiske forhold i barndommen og egen utdanning.

Denne avhandlingen viser behovet for å gjøre et faglig motivert valg av SEP-indikator i studier av helseulikhet. Den understreker også viktigheten av barndomsforhold som bestemmende faktorer for helseutfall senere i livet, og etterlyser dermed politikk rettet mot tidlige barndomsforhold for å utjevne ulikheter og sikre gode livssjanser.

List of papers

The thesis is based on the following papers, which hereafter are referred to as Paper I, Paper II, and Paper III:

I. Lindberg MH, Chen G, Olsen JA, Abelsen B. Combining education and income into a socioeconomic position score for use in studies of health inequalities. BMC Public Health. 2022 Dec;22(1):1-1. doi: 10.1186/s12889-022-13366-8

II. Lindberg MH, Chen G, Olsen JA, Abelsen B. Explaining subjective social status in two countries: The relative importance of education, occupation, income and childhood circumstances. SSM–Population Health. 2021 Sep 1;15:100864. doi: 10.1016/j.ssmph.2021.100864

III. Lindberg MH, Wildman J, Abelsen B, Olsen, JA. The lasting impact of circumstances on efforts and health in adulthood. Submitted March 2023.

Abbreviations

ACLR: Adjacent-category logistic regression

AUD: Australian dollars

BMI: Body mass index

CFC: Childhood financial circumstances

CSDH: Commission on the Social Determinants of Health

EQ-5D: EuroQol five-dimensional instrument

HRQoL: Health-related quality of life

IOp: Inequality of opportunity

LPM: Linear probability model

NOK: Norwegian krone

OECD: Organisation for Economic Cooperation and Development

OLS: Ordinary least squares

SEP: Socioeconomic position

SES: Socioeconomic status

SRH: Self-rated health

SSS: Subjective social status

VAS: Visual analogue scale

WePP: Western Preference Pattern

WHO: World Health Organization

1 Introduction

Social inequalities in people's health are observed at all levels of society: between world regions and countries, within countries, and within cities and communities (1-3). Social inequalities in health are therefore acknowledged by the World Health Organization (WHO) as a global challenge, manifested through the WHO Commission on the Social Determinants of Health (CSDH) (2). The United Nations Sustainable Development Goals recognise that inequalities hamper overall development (4). Moreover, the Organisation for Economic Cooperation and Development (OECD) considers the reduction of social inequalities in health as key to ensuring inclusive growth (5). Thus, social inequalities in health are a policy issue high on the political agenda. Although trends differ across countries, the overall tendency is that inequalities in health persist despite the apparent interest in and efforts to tackle them (5, 6).

One of the recommendations from the WHO CSDH, was to 'measure and understand the problem' (2). However, various measures and methods exist for studying and understanding social inequalities in health. It depends on the health measure, how inequality is calculated, and what socioeconomic indicator(s) are used to group or rank individuals (7). First, health can be measured in many ways and depends on data availability and the health outcomes of interest. Second, regarding the inequality measure, there are various methods in different disciplines, such as the concentration index, relative index of inequality, and regression coefficients (8). Third, the choice of socioeconomic indicator(s) depends on the hypotheses, context, and data availability. While the three most common indicators of socioeconomic position (SEP) are education, occupation, and income (9), other measures can be more relevant in certain contexts. For example, *subjective* measures of SEP have been found to independently predict different health outcomes, capturing different socioeconomic dimensions than objective measures (10). Childhood circumstances are also key to understanding how socioeconomic conditions shape health, especially from a life course perspective (11). All of these issues complicate the precise measurement of social inequality in health, particularly the comparability across studies and countries.

This thesis will primarily address the latter issue, relating to different ways of measuring socioeconomic position in studies of social inequalities in health. First, this thesis investigates the most common indicators of SEP and the potential for applying a composite SEP indicator to measure health. Second, this thesis assesses *subjective* SEP measures and their determinants. Third, the role of (childhood) circumstances as the main socioeconomic dimension is

investigated. Fourth, the thesis will explore how health-related behaviours contribute to social inequalities in health, by disentangling what sources of inequalities that are modifiable by behaviour and what sources that the individual should not be held responsible for.

This introduction will first provide a brief overview of the key concepts of social inequality in health and the research and policy context of social inequality in Norway. Second, it introduces the conceptual and theoretical frameworks of this thesis. This includes a presentation of the prevailing theories of the causal pathways in social inequalities in health, the theoretical foundation of SEP measurement, and an overview of SEP indicators. Finally, the aims of this thesis are presented.

1.1 Social inequality in health

Social inequality in health can be defined as 'systematic differences in health between different socioeconomic groups within a society' (12). Social inequalities in health tend to take the shape of gradients. A social gradient in health (the higher the SEP, the better the health outcomes) is one of the most consistent findings in epidemiological research (13). Regardless of SEP indicators, the type of health outcomes, or the geographical context investigated, studies confirm the same pattern: the distribution of (ill) health is socially patterned (14-17).

Health inequality is not in itself the same as health *inequity*. 'Inequality', strictly speaking, refers to the purely descriptive differences in health and 'inequity'—the avoidable health differences arising from injustice (18). Avoidable inequalities originate from the social environment, whereas unavoidable inequalities are biologically determined (19). The inequity perspective is often taken when considering health inequalities as a societal challenge (12). This is also how health inequality is conceptualised in this thesis—taking the normative position that systematic, avoidable health inequalities are unjust and should be reduced.

Although socioeconomic inequalities in health have been documented for many centuries (20), their resurgence on the health research agenda was largely driven by the launch of the Black Report in the UK in 1980 (21). The report documented that morbidity and mortality rates were much higher among lower occupational classes than among higher ones, despite overall improvements in population health. Similar findings have been reported in other European countries (22) and in the US (23). Research has been facilitated by an increasing amount of available data, such as vital statistics, censuses, comprehensive registries, and population cohort studies following individuals over time, leading to a substantially increased interest in social

inequalities in health (24). Even before the launch of the Black Report, the Whitehall studies following cohorts of civil servants in London were initiated in the 1970s to study the determinants of health inequalities and how they evolved over time (25, 26). In continental Europe, the work by Mackenbach and colleagues studying trends in health inequalities across countries has been widely influential, e.g., (16, 17, 27). A central finding in their work is that countries with highly developed and generous welfare regimes, typically observed in the Nordics, still experience health inequalities similar to those in countries with less generous welfare regimes (28-31). This has been termed the 'Nordic paradox' (29), since intuitively, an expansionist welfare regime ensuring social and economic security should reduce, not increase, inequalities.

1.1.1 Social inequalities in health in Norway

The Nordic paradox has been identified in Norway, which has low social inequality, free higher education, and universal access to national health services financed through taxes. Substantial efforts have been invested into labour market policies aiming to (re)integrate recipients of social services into the labour market (32). Income inequalities are relatively small due to generous unemployment benefits and collective bargaining between the state, employers, and labour unions on behalf of workers, which contribute to wage compression across sectors (33). Nevertheless, inequalities in health are comparable to those observed in less egalitarian European countries (16), and in the US—an entirely different country in terms of public welfare service provision (34).

In Norway, little attention was paid to these trends at the national policy level before 2002. In 2002, a government report to the Storting (Norwegian parliament) set an explicit goal to reduce social inequalities in health as part of public health policy (35). This was followed by the launch of a long-term government strategy to reduce social inequalities in health in 2007 (36). It considered social inequalities along a gradient rather than targeting only those worse off; moreover, it focused on addressing structural factors rather than individual ones (36), thus taking the WHO's social determinants of health approach (2). These efforts were also established by law in the Public Health Act (2011), in which its stated purpose is '… to contribute to societal development that promotes public health and reduces social inequalities in health' (37) (translation by the University of Oslo Law Library (38)). However, these policy efforts have so far not resulted in declining health inequality. Kinge et al. (21) found that income-related inequalities in life expectancy increased from 2005 to 2015. Strand et al. (39)

concluded that although inequalities in mortality for men levelled off between 2000 and 2010, inequalities among women widened during the same period. Finally, Storeng et al. (40), studied trends in disability-free life expectancy and identified increasing educational inequalities, from 1995 to 2017, especially for men,.

Several initiatives have been implemented to target the social determinants of health, as highlighted in the 2007 strategy (e.g., equalising tax reforms, universal coverage of day-care, various reforms in basic education, and prevention of early dropouts from upper secondary school). However, the health sector initiatives set out by the strategy have not been sufficiently implemented (32). These proposed initiatives mainly focused on generating new research-based knowledge and evaluating the implementation of new programmes and reforms, such as how reforms might have differential impacts on different social groups (32). Subsequent welfare reforms outside the health sector, but with large potential consequences for health, such as the Coordination Reform ('Samhandlingsreformen') and the Inclusive Working Life Agreement ('IA-avtalen'), have not been evaluated for their impact on social inequalities in health (41). Therefore, there are still substantial knowledge gaps and few tangible results as to why there is no apparent reduction in social inequalities in health (42).

Some answers might be found in how the Public Health Act was designed and implemented. It transferred part of the responsibility to reduce social inequality in health to the municipal level. However, without sufficient national coordination, this has arguably fragmented the comprehensive efforts that the strategy originally aimed for. For example, while the strategy focused on the social determinants of health approach, it has been found that, in their local approaches to reducing social inequalities in health, many municipalities focused on individualistic measures limited to the health sector (43). Many municipalities with different challenges are more likely to target individualistic measures than structural determinants.

The 2007 strategy expired after ten years and has not been followed up with renewed efforts (42). A 2015 government report (44) addressed social inequalities in health. However, this report largely targeted individuals' health-related behaviour rather than the social determinants of health and focused on the poor-rich gap rather than the social gradient (41).

Another factor that might hamper these efforts could lie in people's awareness around the issue of social inequalities in health. Norway is perceived as an egalitarian country, both internationally and nationally, with a 'passion for equality' and strong faith in the redistributive

ability of institutions (41). Indeed, egalitarianism is deeply embedded in Norwegian culture, which seems to influence how people think of themselves compared with others in terms of class or status (45). Skarpenes and Sakslind (45) suggested that an internalisation of egalitarian values in the Norwegian middle class made people more hesitant to identify themselves as a class separate from other classes. This apparent lack of consciousness of social inequalities might hamper the collective efforts towards reducing inequalities that exist regardless. It could be argued that Norway should have its own 'Black Report' to create more awareness among politicians and the general public to reverse these undesirable trends.

1.2 Conceptual and theoretical framework

1.2.1 Theoretical approaches to socioeconomic inequalities in health

The origin of modern health inequality research can largely be traced back to the Black Report (21). Building on and expanding on the explanatory hypotheses presented in this report, the dominant theories seeking to explain social inequalities in health (46) are outlined below.

The cultural-behavioural approach

The cultural-behaviour approach focuses on the role of socioeconomic inequalities in health-related behaviours (e.g., smoking, diet, physical activity) in explaining the association between SEP and health outcomes; (un)healthy behaviours are shaped and reinforced by the cultural context within which people live (46, 47). For example, certain cultures dominated manual labour and low-income groups in which unhealthy behaviours, such as smoking and drinking, were prominent (24). The literature adopting this approach mainly focuses on the (individualised) behavioural component rather than the cultural component (24). Much of the research following the behavioural model implicitly assumes that some individuals end up with bad working conditions and low incomes due to poor performance in school and are, therefore, unable to understand and act on health education messages coming from governments and public health campaigns. This is posited to be due to certain personal characteristics related to low resilience and coping skills (24). Although this explanation has been deemed insufficient to explain the complex relationship between socioeconomic background and health, health-related behaviours remain an important contributing factor in understanding social inequalities in health, be it a symptom or cause (46).

The materialist explanation

The materialist explanation focuses on income and wealth and their role in accessing health-

related goods and services (such as healthcare, education, diet, transport, and housing), as well as limiting exposure to physical and psychosocial risk factors (24). Unlike the individualist cultural-behavioural approach, the materialist explanation emphasises how structural factors, such as policies and the provision of public services, act in the unequal distribution of resources (47). This implies that societies with smaller income inequalities would have lower health inequalities. However, the exposure to other material determinants of health could still be unequally distributed (47, 48). Countries with low income inequalities and generous welfare arrangements do have comparable or larger health inequalities than more 'unequal' countries (17, 28, 34). Moreover, studies have shown that there are health inequalities, even between groups that would seemingly have very similar material conditions (e.g., individuals with an undergraduate degree vs those with a postgraduate degree) (49, 50). This would support the view that material conditions as determinants of health would be the most relevant in contexts of lower living standards and would as such fail to explain persistence and widening of health inequalities in materially advanced societies. Indeed, improved living standards and decreasing income inequalities in Western Europe have not necessarily been accompanied by a corresponding decrease in health inequalities (29).

The materialist explanation has nonetheless remained prevalent in the literature as there is widespread agreement that material determinants do affect health (46).

The psychosocial explanation

The psychosocial explanation is centred around how feelings of inequality or inferiority might translate into biological mechanisms producing disease; negative feelings arising from individuals' perception of their position in the social hierarchy are internalised through social comparison, triggering stress-related neuroendocrine mechanisms (51, 52). This is closely related to the concept of 'allostatic load', described as the 'wear and tear' on the body resulting from accumulated stress over the time (53). Central for the psychosocial explanatory models are the seminal Whitehall studies, documenting that individuals' employment grade (i.e., their position in the occupational hierarchy) was an independent predictor of coronary heart disease mortality and morbidity (26, 54). This has been further corroborated by studies applying measures of perceived social status that more explicitly capture the psychosocial dimension of socioeconomic factors in predicting health outcomes such as mortality (55), overweight in adolescents (56), self-rated health (10) and stress-induced inflammation (57). Perceived position, or subjective SEP, is considered to be both heavily determined by objective SEP but is also regarded as a separate construct since it reflects socioeconomic dimensions other than

objective SEP (10). The psychosocial explanation is framed as a perspective that could supplement rather than replace other theories, such as the materialist one, in explaining unexpectedly wide health inequalities in settings with high material living standards (58).

The life course perspective

The life course perspective is not a separate theory but an approach that highlights the need to consider the entire life course; people are exposed to different health risks throughout their lifetime, from foetal development into old age (24, 59, 60). For example, Forsdahl (60) hypothesised in the 1970s childhood and adolescent poverty are risk factors for arteriosclerotic disease in adulthood. This literature has expanded extensively and has documented a strong and independent relationship between childhood socioeconomic factors, and health and SEP in adulthood (11, 61). Early life factors are thought to influence health in adults through various pathways. First, early life illness has long-term consequences for adult health directly through the illness itself and indirectly through limited educational opportunities and life chances (62). Second, the 'critical' or 'sensitive' models posit that early-life circumstances or hazards influence specific developmental processes during critical periods of growth, which in turn could increase later-life risk of different chronic diseases or impair cognitive development (24, 62). Third, cumulative (dis)advantage models emphasise how disadvantages tend to cluster and compound initial inequalities over time (63) due to long-term accumulated social, psychological, and biological advantages and disadvantages (47). From this perspective, cross-sectional studies measuring inequalities at one point in time will not capture lifetime or accumulated exposure to various health risks. They will, at best, only identify incomplete relationships. Life course models require data from multiple time points from longitudinal cohort studies or administrative data and registries (64).

The inequality of opportunity (IOp) approach

The IOp approach is not a theory that aims to *explain* social inequalities but rather a theoretical framework to understand and distinguish between 'legitimate' and 'illegitimate' sources of inequalities in health. Originally applied to inequalities in income, the IOp framework posits that the distinction between legitimate and illegitimate inequalities depends on their sources. One of the most prominent scholars formulating this theory is John Roemer (65, 66). In his view, equality of opportunity aims to 'level the playing field' through policy. This will be achieved by targeting inequalities that arise from *circumstances*—'…aspects of an individual's environment and actions which are either beyond his control, or for which we (society) wish not to hold him responsible' (66).

On the other hand, inequalities attributable to different preferences and choices, i.e., factors over which the individual is partly in control, are deemed morally acceptable. Society should compensate people for aspects of the circumstances for which they cannot be held responsible; thus, equality of opportunity is achieved when the outcome is the result of the individual's *effort* only (66). Distinguishing between circumstances and efforts, therefore, rests on individual responsibilities. However, efforts are often hypothesised to be partially determined by circumstances (65), which complicates distinguishing between circumstances and efforts. Therefore, the emphasis on responsibility departs from the widely supported concept of 'equal access for equal need' since this concept does not involve any degree of responsibility in shaping a person's needs (19).

From a health perspective, circumstances are typically captured by socio-environmental factors, such as social and family backgrounds or ethnicity. Efforts are usually captured by lifestyle factors, such as smoking, diet, physical activity, and alcohol consumption, as they are factors considered within the control of the individual (67).

There are two different approaches to inequality measurement in the IOp literature: *ex ante* and *ex post*. The *Ex ante* approach considers only inequalities between people sharing the same circumstances and, thus, focuses only on inequality arising from circumstances (68). The *ex post* approach considers inequalities in health between people who exert the same level of effort (68-70). Therefore, the *ex post* approach also includes efforts when estimating IOp.

The inequality of opportunity framework has gained considerable traction in both theoretical and empirical studies. However, questions have been raised about its credibility and practical meaningfulness for policy, given the many different normative stances on distinguishing between illegitimate and legitimate sources of inequality (71).

1.2.2 Theoretical approaches to the measurement of socioeconomic position (SEP)

The measurement of SEP is closely related to understanding the mechanisms of socioeconomic inequalities in health. In modern health inequality research, SEP—also referred to as social or socioeconomic status (SES), social class, or social standing—is most commonly measured by education, occupation, or income(9). The measurement of SEP has theoretical roots largely in Marxist and Weberian traditions (13, 72).

In the framework inspired by Karl Marx, SEP is defined in terms of classes emerging from their relationship with the 'means of production'; that is, those who own capital and those who do not (13, 72). From this perspective, control over means of production is understood as access to material resources. This is linked to the materialist explanation of health inequalities. The Marxist perspective points to the use of occupation as a SEP indicator, which provides critical access to material resources, employment relations, and different levels of autonomy (9). The Marxist framework has been applied in some epidemiological research on social inequalities in health, such as Wright's classification (72, 73). More recently, it has been used to analyse Marxist class theory using variables such as housing tenure, car ownership, income from property or capital, and autonomy as predictors of various self-reported and biological health outcomes (74).

Max Weber maintained that society is hierarchically stratified along different dimensions (such as education, occupation, or income), forming social groups according to shared characteristics in terms of circumstances, resources, and values. Weber defined these characteristics as individuals' 'life chances', which determine their position in the 'marketplace' (9, 13). He claimed that the prestige associated with people's social positions was just as important for these life opportunities as economic resources (13). The use of indicators such as education, occupation, and income results from the attempt to capture Weber's understanding of social stratification, that is, individuals' life chances (9, 13). Differences in the distribution of individuals' life opportunities are critical for understanding the link between social inequalities and individuals' health (13).

In this thesis, SEP is conceptualised according to Lynch and Kaplan's (13) definition of SEP as '…the social and economic factors that influence what position(s) individuals and groups hold within the structure of society, i.e., what social and economic factors are the best indicators of location in the social structure that may have influences on health'. This definition implicitly underscores the importance of defining the indicators most relevant to the considered health outcome and encourages motivation for the choice of SEP indicator. Moreover, this definition is closer to Weber's concept of life chances than Marx's class division based on capital ownership; this perspective is largely reflected in this thesis.

It is worth noting that other terms that are commonly used to denote SEP: SES, social class, social standing, or other similar terms are frequently used interchangeably, often without reflecting the theoretical origin of these different concepts (72).

Social class is often used to indicate approximately the same concept as SES and SEP but with a different theoretical basis. According to Krieger et al. (75), social class refers to '...social groups forged by interdependent economic and legal relationships, premised upon people's structural location within the economy...'. Here, social class is understood as a relational concept. It is often closely connected to individuals' occupations, as it is commonly defined based on individuals' control in relation to the means of production, echoing Marx (76). In modern settings, social class is frequently understood as groups of occupations, especially in the UK (24).

The distinction between SES and SEP is unclear. Glymour et al. (76) understood SES as a marker of the differences between people and groups possessing resources, such as schooling, earnings, and occupational prestige. They contrast this with SEP, which they consider as a relational concept, indicating how people stand relative to others. Krieger et al. (75) argued that SES distorts the difference between individuals' actual resources and status, which is understood as prestige or rank. Rather, they consider SEP as an aggregate concept encompassing both resource-based factors: income, wealth, and educational qualifications, and prestige-based measures: individuals' rank or status in a hierarchy based on people's access to goods, services, and knowledge, expressed through their education level, occupational prestige, and income (75). This understanding of SEP, therefore, absorbs the Weberian notion of life chances as a construct combining prestige or status and material resources (13).

1.2.3 Measures of SEP

In the literature on social inequalities in health, various indicators are applied to measure SEP. Since SEP cannot be measured or observed directly, researchers depend on proxy measures. A range of indicators is utilised in this literature, and each of them measure different, although to some extent overlapping, aspects of SEP. The choice of SEP measure inevitably involves certain assumptions about how inequalities in health are hypothesised to be influenced by the chosen measure. However, these assumptions are often not stated by the researcher. The ever-growing literature on social inequalities in health tends to apply SEP indicators based on available indicators or what has been done in other studies without a clear motivation for the choice of the specific indicator(s) (72).

Education

In a European context, education is the most commonly applied SEP measure and is often utilised as a generic SEP indicator (46, 72, 77). It is often measured as either the highest level

of education achieved or years of education. Education is most often analysed as a proxy for an individual's cognitive resources and what they can be translated into. Individuals with higher levels of education are more likely to have better and well-paid jobs, afford better housing, and have a higher capacity to process health information. Moreover, they are more likely to have a partner or friends that are highly educated and are as such surrounded with a 'healthy social network' (76, 78). There is a possibility of reverse causality that health causes education; for example, illness during childhood or adolescence could impact school performance and cognitive development (79).

The advantage of using education is that it is easy to measure; stable across the life-cycle; not influenced by changes in (adult) health status, thereby limiting reverse causality; and it captures 'everyone' (i.e., also those who are outside of the labour force) (75). The limitations of education as a measure of SEP are as follows. First, it does not consider the *quality* of education; education, measured as credentials or literacy, could be more informative than the number of years or level (75, 76). The prestige of the school/university a person attends might also be important for SEP. Second, education might not be sensitive enough to measure the magnitude of social inequalities in health since the education period is shorter than, for example, income. Third, using education alone masks the impact of economic fluctuations, social relationships, and conditions on health outcomes (24). Fourth, the share of people pursuing higher education has increased dramatically over the past few decades. Therefore, the size and composition of different educational groups have changed, which might hamper comparability between generations (80).

Despite these limitations, education is a powerful predictor of morbidity, mortality, and healthy behaviours (81-83). Moreover, when the economy becomes increasingly dominated by the service sector, the importance of education increases as a marker of stratification and a ticket for entry into good jobs and other social resources (22). However, even if the education-to-health association is robust, it does not mean that improvements in education will improve health outcomes (76). Some research indicates that education-related health inequalities are partly determined by social and material conditions in childhood; thus, measuring and targeting education alone will be inadequate for reducing health inequalities (24). Moreover, Conti et al. (83) found that selection into education on early life factors accounted for more than half of the observed educational differences in health, depression, and obesity. However, randomised trials have found evidence of early education on adult educational and labour market outcomes (76), which tends to be positively associated with health, although this does not confirm a causal

relationship. There is also quasi-experimental evidence of causal links between education and health; for example, school reforms were introduced to identify the causal effect of years of schooling on long-term illness among men in Germany (84). Nevertheless, the total amount of evidence on the causal effect of education on health is mixed, indicating that education level should not be interpreted and applied as a causal determinant of health, although this is often implicitly assumed (85).

Occupation

Occupation can be measured as occupational prestige, class, category, or employment status. From a health perspective, the occupational setting is important both for the physical environment (e.g., whether individuals are exposed to hazardous work conditions or how physically demanding it is) and for the psychosocial work environment in terms of job control, autonomy, and satisfaction. Moreover, occupation is closely linked to income, indicating that occupation likely picks up some material aspects of the SEP-health association (72). Additionally, occupation reflects social standing and prestige, which could entail certain health-enhancing advantages (9). In addition, with occupation, there could be reverse causality in that an individual's health influences their ability to work.

Occupation is extensively used, especially in the UK, where social class has been conceptualised in terms of people's occupation (9, 24). Today, the UK's most common occupation measure is the National Statistics Socio-Economic Classification, which incorporates employment relations and occupational conditions into occupational classes (86). The advantage of occupation as a measure of SEP is the availability of occupational information in many routine data sources and surveys (72); moreover, it is the main structural connection between education and income (13). However, occupation as a SEP indicator has several limitations. First, it does not capture those who are outside of the labour force, which could underestimate socioeconomic inequalities if not complemented with other SEP indicators. Second, it might be difficult to classify occupations in widely different labour markets when comparing countries. International classifications exist to facilitate this, such as the International Standard Classification of Occupations from the International Labour Organization (87). Third, occupational structures have changed dramatically over the past decades, and occupational classifications may not sufficiently reflect these changes. Fourth, occupation classifications do not necessarily have a natural ordering of categories and are not made to serve as an SEP indicator (77).

When assessing the physical environment in the occupation to health pathway, it is evident that those directly exposed to pollution, noise, and hazardous work conditions have a higher risk of poorer health. Regarding the psychosocial environment, numerous scholars have pointed to increased health risks associated with an unfavourable psychosocial work environment. For example, Marmot et al. (1978 (26), 1991 (54)), found that position in the work hierarchy was a stronger predictor for coronary heart disease than lifestyle risk factors; that is, people's occupational position was in itself a risk factor.

Income

Income is strongly associated with various health-related outcomes, such as life expectancy and mortality (34, 88), cancer screening (89), cardiovascular diseases (90), and self-rated health (91). Income indicators are often based on reported absolute income, in income brackets, or through tax registers. It is commonly measured as household income (often adjusted for household size), or as individual income. The causal pathway from income to health is hypothesised to mainly work through the influence of material circumstances, namely the health-enhancing resources money can buy: a healthier diet, better living standards, and improved access to health services (72). Additionally, an individual's income level might also affect self-esteem and social standing, indirectly impacting health. Reverse causality could also influence this association in that people with worsened health would experience a loss or reduction in income (72), due to an inability to work. This view is more prominent in the economics literature (e.g., Smith (92)), while the income-to-health pathway dominates in the public health literature (22).

There has been debate about whether it is *absolute* or *relative* income that matters for health inequality. The absolute income hypothesis suggests that it is only the individual's own level of income that determines their health, and will not be influenced by changes in the income distribution (18). The relative income hypothesis states that health depends on an individual's level of income within the income distribution, i.e., how an individual's income ranks relative to others (18). A proponent of the relative hypothesis is Wilkinson (93), who argues that it is the degree of income inequality in society, rather than individual income, that determines health.

Income is arguably the measure that most directly captures material resources, often mediated by behaviours (72). However, several limitations warrant caution when interpreting the income to health associations. First, self-reported income is considered sensitive because survey

respondents hesitate to disclose their income, increasing the risk of non-response (72). Nevertheless, this could depend on culture, gender, or age; thus, this sensitivity might not be the same across various groups. Second, income is a relatively volatile indicator of SEP, as it tends to vary throughout life. Therefore, measuring income at one time point might provide an incomplete estimate. Third, the importance of income varies throughout life. It is likely less important for younger and older age groups, for which other SEP indicators better capture their position (72).

The existing evidence on the causal relationship between income and health is mixed, especially regarding the long-term effects of income changes on health (72). This relationship can be confounded by unobserved characteristics correlated with income and health, such as genetic endowments, early life investments, parental SEP, or time preferences (94). For example, Frijters et al. (94) used the reunification of Germany in the 1990s as a natural experiment to identify the causal link between income and health. They found a significant but small increase in health satisfaction, concluding that it remains uncertain whether a causal link between income and health truly exists (94).

Childhood circumstances

Consistent with the life-course perspective, the role of early life socioeconomic circumstances as an important determinant of health in adulthood has gained momentum in the past decades. Forsdahl was one of the first to formulate a hypothesis of the relationship between early-life conditions and adult health (95) after documenting that deprivation in childhood and adolescence, followed by rapid improvements in living standards, was a risk factor for arteriosclerotic heart disease (60). Reviews by Galobardes et al. (96, 97) found a consistent association between growing up in deprived socioeconomic conditions and all-cause mortality in adulthood. Pollitt et al. (98) found that the accumulation of childhood disadvantage was associated with poorer cardiovascular health outcomes. The study by Case et al. (61) indicated that children born into poorer families performed worse on both socioeconomic and health indicators in adulthood.

There are various ways to measure childhood socioeconomic position. Ideally, one would have measures of both socioeconomic conditions and health during childhood from several time points, following the same individuals into adulthood. This is often not possible. However, prospective cohort studies following individuals from childhood to adulthood, such as the 1958 National Child Development Study in the UK, or comprehensive registries observed in the

Nordic countries, provide more precise measurements of childhood SEP, facilitating life course studies (24). However, childhood SEP is most commonly measured by retrospective recall in surveys in which respondents are asked about e.g., parental occupation, parental education, or financial circumstances in childhood; these factors are used as indicators of childhood SEP, although they might suffer from recall inaccuracies or bias (9, 99, 100).

Childhood and parental health indicators are relevant when considering childhood factors that might 'directly' influence health in adulthood. Although birth weight has been documented as a determinant of childhood health (59, 61), this variable is often unavailable without access to registry data. Height can be regarded as a proxy for birth weight and childhood nutrition (101) and has been found to predict cognitive ability and mental and physical health in adulthood (102, 103). Parental health and health-related behaviour are other factors likely to influence the prospects of achieving good health through intergenerational transmission of health and behaviours (104, 105) and would as such be a relevant indicator in studying childhood conditions (67, 106).

Therefore, the strengths and weaknesses of childhood SEP indicators depend heavily on the measurement and study design. As the availability of prospectively collected and comprehensive childhood circumstances data is relatively rare, many studies have relied on retrospective recall. Although there is a risk of recall bias, adult recall of childhood circumstances has been found to be adequately precise for population studies (107).

Composite indicators

Separate SEP indicators can be combined into composite indicators. The rationale for a composite indicator is to combine variables that reflect different SEP dimensions into one measure (108). A composite indicator can measure several aspects of importance for understanding SEP when studying social inequalities in health, which could simplify the interpretation and communication of results (109, 110).

While many ways exist to generate composite indicators, the focus is on individual-level indicators. Composite indicators may be aggregated with weighted or equally weighted components (109). The weighting and aggregation methods are manifold. Some use *a priori* defined weights based on knowledge and assumptions about the relative importance of the indicator's components, whereas others use statistical methods to derive weights. Regardless,

weighting and aggregation depend on assumptions regarding how the composite indicator influences the outcome (109).

Examples of composite SEP indicators from the health inequalities literature are: the Hollingshead index of social status, using predefined weights for education and occupation (111); Duncan's socioeconomic index linking education and income to occupational prestige; and the Nam-Powers occupational status score, based on the education and income level of individuals employed in different occupations (75). More recent examples of composite SEP indicators commonly include education, occupation, and income (112, 113) or education and income only (114, 115).

A common critique of composite SEP indicators is that they mask the relative importance of their components (116) but can also capture the synergies between their different components (117).

Other measures

An example of another SEP measure is wealth, which is believed to capture accumulation of SEP. Wealth includes assets accumulated throughout life, such as inheritance, investments, and savings, typically measured by assets such as house and car ownership. Investments in stocks and bonds tend to increase with wealth. Wealth can differ greatly between households and individuals with comparable incomes. Therefore, wealth constitutes a source of financial resilience, security and power (75). Wealth as a measure of SEP is not relevant in all contexts or for all age groups. In most settings, wealth is more important in the older (retired) segments of the population, for whom income might be less relevant (75) and who have had the time to accumulate wealth throughout their economically active lives.

Area-level SEP or neighbourhood is often used as a proxy for the SEP of inhabitants in a given area, or the characteristics of the place itself are used as an explanatory factor of socioeconomic inequalities in health (9). These are often obtained by aggregating individual-level SEP indicators in demarcated areas, such as the proportion with higher education, the proportion of unemployed, and median income. Related to this, although not the same, are deprivation indices such as the Townsend Deprivation Index, which are composite measures of aggregate, individual-level SEP measures. Deprivation indices are commonly used, especially in the UK (9).

Monetary resources are less relevant in some contexts, particularly in low-income settings. In this case, SEP might be more precisely measured by the kinds of assets people have, for example, whether they have a car or bicycle, a TV, or livestock. Housing conditions and overcrowding can also measure SEP in certain contexts (72).

Although this overview of some SEP indicators used in the literature is not exhaustive, it provides an impression of the multitude of measures, indicating that the choice of measure clearly depends on the context and availability of data. It is also important to emphasise that SEP indicators are not interchangeable. The correlation between education and income is often moderate, and earnings can vary substantially within the same level of education and may interact with ethnicity/minority status, age, or gender (77). Therefore, choosing the 'right' indicator(s) hinges on how the researcher hypothesises the pathway from SEP to health.

Interaction or confounding factors

Although not measures of SEP, there are factors that are likely to interact with or confound the relationship between socioeconomic factors and health. Sex, or gender when perceived as a social construct, is such an example. Research on gender inequalities in health has mainly focused on the ways in which gender interacts with socioeconomic aspects of health, given the role of gender differentials in educational attainment, labour market opportunities, or earnings (118). As with SEP, gender is also shaping individuals' life chances and therefore the potential to lead a healthy life (119). Since gender inequalities to a large extent are socially derived, this means that they can be avoided (2), also because of the behavioural component that contributes to gender inequalities in health (120).

Although age is a factor that inevitably eventually will influence individuals' health, age has been found to differentially impact health by SEP: e.g., Kim and Durden (121) found that both education and income were attributable to widening inequalities in physical impairment across adult ages.

Ethnicity is not applied in the data material in this thesis, but still merits mention, as it is a common factor by which to study health inequalities or through its differential impact with SEP, especially in the US, Canada, Australia, and New Zealand (46). In these countries, ethnic health inequalities are of similar magnitude as socioeconomic inequalities. Ethnicity is socially constructed, in that it involves components such as culture, language, and history (46). Ethnicity

has also been found to be differentially associated with cardiometabolic risk factors according to subjective SEP (122).

1.2.4 Subjective socioeconomic position

Subjective SEP, more commonly termed subjective social status (SSS), can be defined as how individuals perceive their own placement in the social hierarchy (123). It is a separate concept from the objective indicators described above, posited to reflect not only the socioeconomic dimensions captured in measures such as education, occupation, and income but also personal characteristics, such as behaviours, values, and attitudes (55). It has also been argued that subjective SEP captures 'lifetime SEP' since it is likely that the current perception of own social position incorporates lifetime accomplishments (10) and an evaluation of average past, present and future SEP, called 'cognitive averaging' (124).

Research on subjective SEP as a determinant of health and health inequalities was scarce until the early 2000s (125). Since then, this literature has expanded, documenting an association with health independent of objective SEP measures and contributing to understanding social inequalities in health (10, 55, 124, 126). Some studies have found that subjective SEP better predicts health than objective ones (127).

Various measures have been used to measure subjective SEP. Singh-Manoux (128) mentioned variables that capture individual-level psychosocial factors (depression, hopelessness, and hostility) and structural factors (linked to work conditions). An example of a single-item measure is 'subjective class identification, in which respondents are asked to place themselves in one of five classes: upper, upper middle, middle, working, or lower (123, 126). Macleod et al. (129) applied a measure indicating subjective position according to whether they see themselves as 'managers', 'foremen', or 'employees'. The most common measure of SSS is the MacArthur Scale of SSS, first introduced by Adler et al. (125). It is a single-item measure that evaluates individuals' perceived position relative to others, formulated in terms of education, occupation, and income. It has been widely applied to different geographical settings, populations, and population subgroups, providing a large basis for comparison. Furthermore, it is easier to measure than the most common objective SEP indicators, each with different shortfalls: moreover, it is more applicable to different kinds of populations, as it can be meaningfully applied in younger age groups and among people outside of the labour force, etc. (126).

The use of subjective SEP as a determinant of health is closely related to the psychosocial explanatory model in that subjective SEP is hypothesised to capture the feelings associated with the perceived position in society. For example, Wilkinson (52) found that low social status was correlated with social anxiety, which in turn predicted poor health. Conversely, a sudden *boost* in status in terms of winning a Nobel Prize was found to increase life expectancy by 1-2 years compared to Nobel Prize nominees (130). Moreover, Cundiff et al. (131) found that psychosocial vulnerability mediates the association between subjective SEP and health. Therefore, subjective SEP could capture elements of experienced psychosocial stress and allostatic load (53, 58). These examples support the need to complement materialist understandings of the relationship between SEP and health with a psychosocial approach.

1.2.5 Measures of health

Health can be defined as '…a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity' (132), as in the WHO constitution from 1948. This definition has been widely criticised. First, it implicitly rejects the idea that people adapt to various health conditions or impairments and still enjoy physical, mental, and social well-being (133). Second, it does not distinguish the severity of different health conditions (134). Third, its 'completeness' is limitless and may lead to overmedicalisation (135). Fourth, Saracci (136) argues that it is closer to a definition of happiness than health and will consequently distort the distribution and allocation of resources in health systems by following a principle of happiness for every citizen rather than equity and justice in the delivery of health care. Fifth, it fails to account for how social determinants influence the distribution of diseases and health and could therefore worsen health inequalities (137).

Alternative definitions of health have been proposed. The Ottawa Charter defined health understood as social and personal resources and physical capacity (138). Patrick et al. (139) emphasised individuals' level of function in their understanding of health, in which optimal function is defined in relation to 'society's standards of physical and mental well-being, including the performance of activities usual for a person's age and social role' (139).

Defining health is a complex task. It is even more complicated to *measure* health. In this thesis, two *self-reported* measures of health were applied. Therefore, the focus of this study will be on self-reported health measures.

Self-rated health (SRH)

Although health status can be measured in many ways, one of the most common measures of general health status is self-assessed or self-rated health (SRH) (140). SRH is obtained from a single-item Likert scale asking people to rate their health, with four or five response categories ranging from *poor* to *excellent* health, or similar wordings. SRH is a powerful predictor of objective health measures, such as mortality (141, 142) and healthcare use (143). However, concerns have been raised regarding its reliability in terms of differential reporting by SEP (144) and understanding what SRH actually measures—whether a change in SRH reflects differences in physical or perceived health (145).

Health-Related Quality of Life (HRQoL)

Another broader health measure is health-related quality of life (HRQoL). HRQoL can be defined as '[h]ow well a person functions in their life and his or her perceived well-being in physical, mental, and social domains of health' (146). Therefore, it is a multidimensional concept that goes beyond direct measures of health, capturing the impact of health on quality of life (147, 148).

Measures of HRQoL can be broadly categorised into disease-specific vs generic measures. Disease-specific measures assess how patients experience living with certain diseases or conditions (149). Generic measures have been developed to assess any health condition or intervention and can be applied to the general population (149). Generic measures can be divided into non-preference-based and preference-based measures. Non-preference-based measures produce scores based on different HRQoL dimensions. An example is the 36-item short form measure. In preference-based measures, a set of preference weights is attached to each dimension, enabling utility value calculation for each health state (150). Preference-based measures allow for a combination of length of life and health status, in which the length of life is weighted against health status or quality of life (151). An example of a commonly used preference-based measure is the EuroQol five-dimensional descriptive instrument: the EQ-5D (152).

1.3 Aims of the thesis

Overall, this thesis aimed to explore different ways of measuring social position to identify social inequalities in health, focusing on objective SEP, subjective SEP, and childhood circumstances; and assessing the added impact of lifestyle. These were further divided into three specific aims and hypotheses.

How do different SEP indicators predict overall SEP, and can a composite indicator replace the use of separate indicators in estimating health inequalities?

We hypothesised that the higher the level of the SEP indicator, the higher the overall SEP. Furthermore, a composite SEP indicator could perform better than separate SEP indicators in estimating inequalities in HRQoL..

What is the relative importance of objective and childhood socioeconomic determinants of subjective SEP?

We hypothesised that education, occupation, income, and also childhood circumstances were significant determinants of subjective SEP.

How do inequalities arising from (childhood) socioeconomic circumstances and inequalities arising from modifiable behaviours—i.e., lifestyle-related indicators—predict health?

We hypothesised that there were inequalities arising from circumstances and that having a healthy lifestyle would be associated with improved health.

2 Materials and Methods

In this section, the data sources, study samples, included variables and statistical analyses will be presented.

2.1 Data sources

2.1.1 The Tromsø Study

The Tromsø Study is a comprehensive population cohort study conducted in the municipality of Tromsø in Northern Norway. Tromsø is the region's largest municipality, with approximately 78,000 inhabitants (153). Most of the municipality's inhabitants reside in urban areas (90 % in 2021 (153)). The population of the Tromsø municipality is similar to the general population in terms of age and sex (154), although it has a slightly larger share of people with higher education (155).

The Tromsø study came about as a combined risk screening and research study in response to the high rates of cardiovascular morbidity and mortality in Northern Norway compared to the general Norwegian population (156). The first wave of the survey was conducted in 1974; currently, a total of seven waves have been conducted, referred to as Tromsø 1-7. The scope of the survey has expanded significantly. It now includes a wide range of topics in addition to cardiovascular diseases, such as cancer, diabetes, physical activity and diet, adolescent health, ageing and dementia, lung disease, mental health, intoxication, chronic pain, musculoskeletal disorders, oral and dental health, and antimicrobial resistance. The collected data includes questionnaires, interviews, biological samples, and clinical examinations (156).

From Tromsø 4 and onwards, the data collection was split into two visits. The first visit encompassed the total sample, with examinations and questionnaires (one short questionnaire with general information (Q1) and a more comprehensive questionnaire (Q2)) covering topics such as mental and somatic health, family health history, symptoms and disease, socioeconomic information, and lifestyles. Examinations included measurements of height, weight, waist and hip circumference, blood pressure, heart rate and oxygen saturation, and biological sampling, among others. In the second visit, random sub-samples were invited for more comprehensive examinations, such as cognitive tests, physical function tests, and examinations of the eye, lung, and heart (156). This thesis only includes data from the Q1 and Q2 questionnaires in Tromsø 6 (Appendix C) and Tromsø 7 (Appendix D).

More than 45,000 individuals participated in at least one of the surveys (156).

2.1.2 The 'SEP Survey'

Paper II is based on an anonymous, online survey entitled 'People's views on socioeconomic position', which was sent to representative samples of the adult populations in Norway and Australia from December 2018-February to 2019. Hereafter, it will be referred to as the 'SEP Survey'.

The survey was developed on the online survey platform, Qualtrics (www.qualtrics.com). Respondents were recruited by a global panel company, Cint (www.cint.com), from among its panel members. To increase the question response rate, a reminder was shown on the screen before moving on to the next page when the respondent had left the questions unanswered. The respondents received a small monetary reimbursement after completing the survey.

The survey was composed of three parts: Section A consists of a discrete choice experiment, that is, a series of pairwise comparison tasks to elicit respondents' preferences on how socioeconomic factors determine a person's SEP in society; section B contains validated instruments on respondents' health and subjective well-being; and section C consists of questions on the participants' background characteristics. This thesis used questions from section C only (see Appendices F and G).

2.2 Study samples

2.2.1 Paper I

Paper I is based on Tromsø 7, conducted in 2015-2016. A total of 21,083 participants took part, corresponding to 65 % of the 32,591 residents aged ≥40 who were invited to participate (156). We excluded respondents older than 80 years due to a low response rate (37 % vs 66.4 % in those below the age of 80) and to avoid severe education cohort effects, as there were only 20.8 % with higher education vs 50.9 % among those below 80. This left a sample of N = 20,322. For the analyses, respondents with missing values for the education and income variables were excluded, corresponding to 4.5 % of the sample.

2.2.2 Paper II

Paper II used the SEP Survey conducted in Australia and Norway. A targeted sample size of N = 1,400 was applied for both countries, using demographic quotas for the actual age and sex distribution in the two countries. Among the Australian and Norwegian respondents, N = 1,920

and N = 2,418, respectively, consented to participate. Of these respondents, some were excluded if they either did not submit the survey or the quota was full (N = 249 in the Australian sample; N = 665 in the Norwegian sample). Similarly, responses were excluded if they failed to meet quality thresholds, such as spending less than five minutes on the survey (N = 248 in Australia and N = 353 in Norway). Observations missing for the subjective SEP variable were also excluded from the analyses (N = 0 and N = 6 in the Australian and Norwegian samples, respectively). Another observation (N = 1) was excluded from each sample because of improbably high reported ages. The final samples were N = 1,422 Australian respondents and N = 1,393 Norwegian respondents.

Post-stratification weights were applied after data collection to match the respondent data with population statistics with regard to age and sex.

2.2.3 Paper III

Paper III is based on data from Tromsø 6 and 7, conducted in 2007-2008 and 2015-2016, respectively. In Tromsø 6, invitations were sent to four groups. First, to the individuals who participated in the extended clinical examinations (the second visit) in Tromsø 4; second, to a random sample of 10 % among those aged 30-39; third, to the municipality's inhabitants aged 40-42 or 60-87 years; and fourth, to a random sample of 40 % of the municipality's inhabitants aged 43-59 years. Of the 19,762 respondents invited, 12,984 participated, which equates to an attendance rate of 65.7 % (157, 158). See the description of Tromsø 7 in the description of Paper I.

Paper III included only respondents who participated in both Tromsø 6 and Tromsø 7 (N = 8,903). We restricted the sample to include only non-missing values for the two outcome variables (HRQoL and SRH). This resulted in N = 8,086 for cross-sectional analyses of Tromsø 6, N = 8,457 for cross-sectional analyses of Tromsø 7, and N = 7,708 for panel analyses of both the waves.

2.3 Included variables

An overview of all the included variables is reported below, followed by a detailed description of each variable.

Table 1: Overview of included variables in Papers I-III

	Outcome variables	Explanatory variables	Confounders	Data source
Paper I	Subjective SEP HRQoL: EQ-5D VAS	Education level Income bracket	Age Sex	The Tromsø Study: Wave 7
Paper II	Subjective SEP	Education level Occupational category Income Childhood financial circumstances Mother's education Father's education	Age Sex	SEP Survey
Paper III	HRQoL: EQ-5D SRH	Childhood financial circumstances Height Mother's education level Own education level Parental somatic health Parental mental health Parental substance abuse Age* Sex* BMI Smoking status Physical activity Alcohol consumption	Age* Sex*	The Tromsø Study: Waves 6 and 7

Note: SEP=socioeconomic position; HRQoL=health-related quality of life; EQ-5D=EuroQol five-dimensional descriptive system; VAS=visual analogue scale; SRH=self-rated health; BMI=body mass index.
**Age and sex are included as circumstance variables in some analyses and as potential confounders in others (see description of Paper III in Section 2.3.3).*

2.3.1 Paper I

Outcome variables

The analyses were performed in two steps and included three outcome variables. In the first step, subjective SEP was used as the outcome variable to calculate a composite score for SEP. Subjective SEP was measured with the question: *I consider my occupation to have the following social status (if you are currently out of work, think about your latest occupation)*. This was rated using five response categories: *very high; fairly high; middle; fairly low; very low*. Owing to few observations in the lowest category (<1 %), the two bottom categories were collapsed into a category for *low* status. This variable is inspired by Michael Marmot's work (e.g., (26, 54, 159)) on the role of social status derived from individual's occupation as an important determinant of health.

In the second step, two measures of HRQoL were used: the EQ-5D and the visual analogue scale (VAS).

The EQ-5D is a generic measure of health status developed by the EuroQol Group, providing a measure that describes health across five dimensions. It is used for studies covering a wide range of patient populations and in general population studies (152). The EQ-5D describes health in five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression (160). There are two different versions. One version has three severity levels (EQ-5D-3L) (161): *no problems*, *some problems* and *extreme problems*; and one version has five severity levels (EQ-5D-5L) (162): *no problems*, *slight problems*, *moderate problems*, *severe problems*, and *unable*. Given that the EQ-5D is a preference-based instrument, a value set (or preference weights) is attached to every level in each dimension. Value sets have been developed for various countries to reflect the preferences of different populations (152).

The EQ-5D-5L was used (162). The EQ-5D is calculated as a summary number (index value) for the analyses in which 1 represents full health, and 0 represents a health state equivalent to being dead (152). In the absence of a Norwegian value set, an amalgam value set combining the four Western countries' published value sets was applied: the Western preference pattern (WePP) (163).

The VAS is a self-rated measure describing people's overall health ranging from 0-100, and is frequently used in combination with the EQ-5D (152). Respondents are shown a drawing of a VAS and asked: *We would like to know how good or bad your health is today. This scale is numbered from 0-100. 100 means the best health you can imagine. 0 means the worst health you can imagine. Please insert a number between 0 and 100 here.* The VAS was converted to a [0-1] interval for the analyses.

Predictor variables

Education level was recorded asking *What is the highest levels of education you have completed?* and categorised in line with the International Standard Classification of Education: *primary education up to ten years*, *upper secondary* (including vocational school), *undergraduate* (less than four years of higher education), and *postgraduate degree* (four years or more of higher education).

Income was recorded as *The household's total taxable income last year (include income from work, social benefits and similar)*, i.e., the combined gross income of adults in the household, in eight income brackets (per NOK 1,000): <150; 151-250; 251-350; 351-450; 451-550, 551-750; 751-1,000; and >1,000. These were collapsed into four categories attempting to achieve a

relatively similar distribution (per NOK 1,000): *Low*: NOK ≤450; *Lower middle*: NOK 451–750; *Upper middle*: NOK 751–1,000; and *High*: NOK >1 million.

Age (analysed as a continuous variable) and sex were included as potential confounders.

2.3.2 Paper II

Outcome variable

Subjective SEP was measured using the MacArthur Scale of SSS, developed by the MacArthur Research Network on Socioeconomic Status and Health, first introduced in the literature by Adler et al. (125). The MacArthur Scale is a single-item measure of individuals' perception of their social rank relative to others, originally developed to investigate the role of SSS as a determinant of health (124, 125). Since its introduction, it has been widely applied to various populations and settings.

The respondents were shown a drawing of a ten-rung ladder, accompanied by the following text:

> *Think of this ladder as representing where people stand in society. At the top of the ladder are the people who are best off – those who have the most money, most education and the best jobs. At the bottom are the people who are worst off – who have the least money, least education and the worst jobs or no job. The higher up you are on this ladder, the closer you are to people at the very top and the lower you are, the closer you are to the bottom.*
>
> *Where would you put yourself on the ladder:* _____

Figure 1: Drawing of the MacArthur Scale of SSS as included in the questionnaire. As applied in Allen et al., 2014 (164).

The MacArthur scale of SSS was analysed as a continuous measure ranging from [1-10], with higher values denoting higher SSS. While the original term is SSS, we used the term subjective SEP to contrast it with *objective* SEP, which includes the more traditional measures of SEP—education, occupation, and income.

Predictor variables

Education was recorded by the question: *Please choose the level that best describes your education* out of four levels. These were *primary or secondary school* (primary education <10 years), *certificate or diploma* (upper secondary), *bachelor's degree* (undergraduate degree) and *postgraduate degree*. For the analyses, the upper secondary level was used as the reference category because there were few respondents in the primary education category in the Norwegian sample.

Occupation was measured using the following question: *Please tick the level that best describes your own occupation. If you are retired, please tick the level that best describes your latest occupation*. These levels were split into five descriptive categories: *managers and professionals*; *technicians and trades workers*; *sales, clerical and service workers*; *machinery operators; drivers and labourers*; and *not in the workforce (e.g., student, unemployed, homeworker)*. Occupation was analysed in three categories; *managers and professionals* and *not in the workforce* were retained, and the three others were collapsed into *other professions*.

Income was measured as gross annual household income: *Please tick the level that best describes your pre-tax or gross annual household income*. There were ten income brackets in the Australian questionnaire and eight brackets in the Norwegian questionnaire. The income brackets were regrouped into five income groups to achieve similar distributions across income categories in the two samples. These were *low*, *lower middle*, *middle*, *upper middle*, and *high*. The *low* income group corresponds to AUD <35,000 and NOK <349,000; the *lower middle* group corresponds to AUD 35,001-65,000 and NOK 350,000-699,000; the *middle* group corresponds to AUD 65,001-100,000 and NOK 700,000-849,000; the *upper middle* group corresponds to AUD 100,001-160,000 and NOK 850,000-1,199,000; and the *high* group corresponds to AUD >160,001 and NOK ≥1,200,000.

Childhood SEP was measured using three variables: childhood financial circumstances (CFC), mother's education level, and father's education level. CFC was recorded by asking, *What was your family's financial situation during your childhood?*. There were five response options:

very good, *good*, *neither good nor bad*, *difficult*, and *very difficult*. *Very difficult* was merged with *difficult* into one *difficult* category due to few respondents. Both mothers' and fathers' education was recorded as the highest completed education level of four, with the same categorisation as for education. We dichotomised the mother's and father's education variables into the *lower than tertiary* category (primary education up to ten years, and upper secondary and vocational school) and a *tertiary education* category (undergraduate and postgraduate degrees).

Age (analysed as a continuous variable) and sex were included as potential confounders.

2.3.3 Paper III

Outcome variables

Two different health outcomes were assessed: self-rated health (SRH) and HRQoL. SRH was obtained from the question, *How do you in general consider your own health to be?*. This was rated as *Very bad*, *Bad*, *Neither good nor bad*, *Good*, or *Excellent*. SRH was dichotomised with *good health* as the cutoff value.

HRQoL was measured using the EQ-5D. Tromsø 6 applied the 3-level (3L) version, while the 5-level (5L) version was used in Tromsø 7. Paper III applied the UK value set for 3L (165), and the English value set for 5L (166). When analysing the two waves as a panel (i.e., analysing the same individuals at the two time points), the UK crosswalk value set for the 5L version was used, applying the 3L UK value set on the 5L version (167). This was necessary to achieve the same scale length.

Predictor variables – circumstances

In Paper III, the explanatory variables were grouped into either circumstances or efforts. This is based on the IOp framework (see Section 1.2.1). Circumstances are defined as factors beyond the control of the individual.

CFC was obtained using the question: *How was your family's financial situation during childhood?*. Options ranged from *Very good*, *Good*, *Difficult* and *Very difficult*. *Very difficult* was merged with *difficult* into one *difficult* CFC category for the analyses. We found that the reporting of CFC differed somewhat between Tromsø 6 and 7, mainly in terms of reporting *very good* in Tromsø 6 and *good* in Tromsø 7, or vice versa. Therefore, we coded the CFC variable as *good* if the respondents reported CFC as *good* in either Tromsø 6 or Tromsø 7.

Education was recorded as the highest completed level of education, as in Paper I. However, in Tromsø 6, there were originally five response categories, as vocational school was a separate category (in addition to upper secondary education). These two categories were collapsed into one (*upper secondary education*) for the analyses.

Maternal education is relevant as a circumstance variable since it is often considered an important determinant of children's health (168, 169). However, it was only included in the supplementary analyses because of its negligible contribution to the model. It was recorded similarly as own education, as the highest attained education level out of four. For the analyses, the undergraduate and postgraduate degree categories were collapsed into one category for higher education.

Height was analysed as a circumstance because it can be regarded as a proxy for birth weight and early-life nutrition (170, 171). Height was objectively recorded by a research technician. For the analyses, height was standardised by 5-year age groups. The age-standardised height variable was split into the 20 % lowest and 20 % tallest share, using 60 % of 'normal' height as the reference.

Three variables measuring parental health were analysed as circumstances: parental somatic health, parental mental health, and substance abuse problems in parents. Each was measured separately for the mothers and fathers. The parental somatic health variables were composed of the following questions: *Has anyone in your close biological family had* [disease/condition]—*Mother?/Father?* for the cancer diagnoses, and *Mother/Father has or has had* [disease/condition] for the other conditions. The maternal somatic health variable considered colon cancer, breast cancer, angina (chest pain), cerebral stroke/brain haemorrhage, myocardial infarction before age 60, diabetes, or asthma. The paternal somatic health variable was composed of the same diagnoses, except for breast cancer, which was replaced with prostate cancer. Maternal and paternal somatic health variables were categorised into three groups: zero reported conditions, one condition, and two or more conditions (coded as 0, 1, and 2, respectively). Having two or more diagnoses was defined as having multi-morbidity, in line with the literature, e.g., Johnston et al. (172). Parental mental health combined questions regarding whether the *mother* or *father has* or *has had psychological problems*. This variable was coded as '1' if the respondent reported that either parent had mental health problems and '0' otherwise. Parental substance abuse combined questions regarding whether the *mother* or *father has* or *has had problems with substance abuse*. This variable was also dichotomised into

whether either parent had problems with substance abuse (yes:1; no:0). Parental health variables were only measured in Tromsø 7.

Age and sex capture biological determinants of health, being outside the control of the individual. They are, therefore, primarily analysed as circumstances unless otherwise stated.

Predictor variables – efforts

Efforts are the factors over which an individual is in control and are modifiable. Efforts were measured using lifestyle indicators and conceptualised as having a healthy lifestyle or making efforts to improve one's health.

Body mass index (BMI) combined weight and height (kilos/metres^2) and were measured by a research technician. BMI is regarded as a risk factor for various lifestyle-related diseases. For the analyses, BMI was divided into the following categories: normal weight (BMI <25), low overweight (25-27.49); high overweight (27.5-29.9); and obese (≥30). BMI was also analysed on a continuous scale in one of the analyses in the Appendix.

The physical activity variable was composed of questions on frequency (*How often do you exercise [i.e., walking, skiing, swimming, or training/sports]?*) and duration (*For how long time do you exercise [give an average]?*). These were combined to achieve a measure of physical activity expressed in minutes per week. Next, this was categorised as *inactive* (<60 minutes/week), *moderately active* (60-149 minutes/week), and active (≥150 minutes/week).

Smoking status was obtained using the following questions: *Do you/did you smoke daily?*. The possible responses were: *Never*; *Yes, now*; and *Yes, previously*. Smoking status was dichotomised into *non-smokers and previous smokers* (coded as 0) versus *current smokers* (coded as 1).

Alcohol consumption was recorded as frequency with the question, *How often do you usually drink alcohol?*, with the following response options: *Never*; *Monthly or less frequently*; *2–4 times a month*; *2–3 times a week*; and *4 or more times a week*. The former two were collapsed into a category for *infrequent drinkers*; the 2-4 times a month category was retained, and the latter two were classified as *regular drinkers*.

2.4 Ethics

The Tromsø Study was approved by the Regional Committees for Medical and Health Research Ethics (REK North) for Tromsø 6 (ID:2009/2536) and Tromsø 7 (ID:2014/940). All participants provided written informed consent before admission into the study. Observations from participants who withdrew their consent were excluded before the data was handed out from the Tromsø Study. This PhD project was approved by REK North in May 2019 (ID:2019/607) (Appendix B).

The SEP Survey was approved by the Monash University Human Research Ethics Committee (project ID:17490).

The Tromsø Study and the SEP Survey were conducted in accordance with the Helsinki Declaration of 1964 and its later amendments (173).

2.5 Statistical analyses

All three papers reported descriptive statistics of the sample(s), with mean and standard deviation (SD) for continuous variables and frequencies (N) and proportions (%) for categorical variables. All statistical analyses were conducted using Stata © versions 15.1 or 17.0 (Stata Corporation, College Station, Texas).

2.5.1 Paper I

In Paper I, adjacent-category logistic regression (ACLR) was used to generate weights for a composite SEP score. Subjective SEP was the outcome variable, with four educational levels and four income groups as predictor variables, controlling for age and sex. ACLR is an alternative to classic ordered logistic regression, which was rejected because of a breach of the parallel odds assumption. There are other alternatives to ordered logistic regression, such as multinomial logistic regression. However, because the outcome variable is ordered (the higher the value, the higher the subjective SEP), we chose a model that would maintain this property. The ACLR did this in addition to relaxing the assumption about parallel odds. In this method, each response category of the outcome variable is compared with the next larger category. That is, the *low* subjective SEP category is compared to the *middle* category; the *middle* is compared to *fairly high*; and *fairly high* is compared to *very high*. The effect of the beta coefficients are assumed to be constant for each adjacent pair (174).

The four-level subjective SEP ($sSEP$) variable was modelled as a function of education ($Educ$), and income (Inc). The education and income variables are coded as dummies, with the lowest level as the reference level for each variable. Sex and age were included as control variables (X) (Eq. 1):

$$sSEP = f(Educ, Inc, X) \qquad (1)$$

The regression coefficients in Eq. (1) were applied as weights for the education and income levels in generating the composite summary SEP score. The education and income level dummies were multiplied by their corresponding regression coefficient, and subsequently summed together into a score predicting individual *i*'s SEP for every *j*th level of education and income (Eq. 2):

$$SEP_i = \sum_{j=1}^{k} \beta_j * Educ_{ij} + \sum_{j=1}^{k} \gamma_j * Inc_{ij} \quad (2)$$

To apply the composite SEP score to predict variation in HRQoL for every individual i, we ran two ordinary least square (OLS) analyses: one for the EQ-5D and one for VAS, using the composite SEP score as the main predictor variable, controlling for age and sex.

$$HRQoL_i = \beta_0 + \beta_1 SEP_i + \beta_2 age_i + \beta_3 sex_i + \varepsilon_i \qquad (3)$$

Several sensitivity analyses were performed. First, we reran the ACLR analyses in Eq. (1) stratified by age groups (40-49, 50-65, and 66-79) and sex. Second, we ran the ACLR analysis excluding all respondents not currently in the workforce, which limited the sample to N = 13,371. This was done to investigate whether those who were currently in the labour force evaluated their subjective SEP—closely linked with occupation—differently than the full sample, which included retired people and others outside the workforce. Third, since the income variable is likely to be sensitive to household size, we tested equalising it according to marital status, that is, for those reporting living with someone in their household.

Fourth, we conducted split-sample analyses by randomly splitting the sample into two (subsamples 1 and 2), before rerunning Eq. (1) for both samples. Running Eq. (2) using the derived weights from Subsample 1 to generate a composite SEP score, we tested how well this composite SEP score predicted HRQoL on Subsample 2 Eq. (3). These results were compared with the results from the main analysis based on the composite SEP score coefficient size and the R^2.

2.5.2 Paper II

Descriptive statistics were reported according to country and sex. The mean subjective SEP scores were reported by all explanatory variables: education level, income category, occupation category, CFC category, and parental education level. We tested the differences in subjective SEP scores between Australia and Norway using independent sample t-tests. The distributions of subjective SEP in Australia and Norway are displayed as histograms.

OLS regression analysis was performed to investigate how the three objective SEP indicators (education, occupation, and income) and childhood SEP (CFC and parental education) predicted subjective SEP. All the analyses were controlled for age and sex. We tested for normally distributed residuals.

Three OLS models were used in the main analyses. Education and income were regressed on subjective SEP in Model A, while in Model B, occupation was added; Model C included childhood SEP. Wald tests were used to determine whether the model coefficients in the Australian and Norwegian samples differed significantly.

Reflecting how subjective SEP is recorded in the questionnaire (in terms of the three objective SEP indicators), we first analysed the adult *current* SEP predictors in Models A and B. This follows other studies that examined the association between objective and subjective SEP (175). Next, we added childhood SEP to assess its importance as a predictor of subjective SEP after controlling for the three objective SEP determinants.

Shapley value decomposition was applied to identify the relative importance of the different subjective SEP determinants. This decomposition method measures the marginal contribution of each explanatory variable to the model's explained variance, R^2. It adds any given explanatory variable to the model, weighted by the number of permutations in a sub-model excluding this explanatory variable (176). Therefore, the Shapley value reports the value of including an explanatory variable in the model as a share of explained variance (177)—the larger the value, the greater the explanatory variable's relative contribution as a determinant of subjective SEP.

Supplementary analyses of sex and age interactions with subjective SEP determinants were conducted, as well as analyses stratified by sex. The interactions between the SEP variables were also tested. Finally, we assessed whether having a higher education level than any of their

parents influenced the reporting of subjective SEP by supplementing Model C with a dummy for 'educational mobility'.

2.5.3 Paper III

Paper III was split into two main parts: the *ex ante* analyses, considering circumstance variables only, and *ex post* analyses, in which effort variables were included. Analyses were either conducted cross-sectionally on the Tromsø 7 sample or analysed as panel data to estimate the change from Tromsø 6 to 7.

Juárez and Soloaga (178) proposed a regression-based approach to estimate *ex ante* IOp in health. This produced an *ex ante* IOp estimate of the variation in the outcome due to the observed circumstances. The IOp estimate for HRQoL—a continuous variable—was variance (corresponding to R^2). For SRH, a dichotomous variable IOp was estimated as the dissimilarity index (D-index). The D-index can be interpreted as the difference in the probability of reporting good or excellent health across the distribution of circumstances, compared with the average probability of reporting *good*/*excellent* health in the population as a whole (179). These estimates were built on two regression models: an OLS model for HRQoL and a probit model for SRH. In reporting the underlying regression models for SRH, the results of a linear probability model (LPM) were reported rather than the probit estimates to ease interpretation. This was because the LPM coefficients did not differ substantially from the probit model's average marginal effect estimates. Next, the relative importance of each circumstance variable's contribution to IOp in health was estimated using Shapley value decomposition. These analyses were rerun and stratified by sex and age groups (<55, 55-69, and ≥70 years) in the supplementary analyses. Moreover, since the HRQoL distribution was skewed, the *ex-ante* analyses were supplemented by unconditional quantile regression analyses to investigate whether the estimates and relative contribution of circumstances varied across the distribution.

Effort variables were added in the *ex post* analyses. Transition matrices reporting how respondents transitioned across or remained at different levels of effort (BMI, smoking, physical activity, and alcohol consumption) from Tromsø 6 to 7 were calculated.

The indirect influence of circumstances channelled through effort was assessed by combining circumstances and efforts in analyses of health. This was done in two steps: first, a model (OLS for HRQoL and LPM for SRH) was run with efforts as the only regressors, adjusted by age and sex. Second, circumstances were added to assess their indirect influence on health by assessing

how the effort coefficients changed compared to the model with efforts only. In the supplementary analyses, we estimated how circumstances directly predicted each effort variable.

Fixed-effects panel regression analyses were conducted to estimate how the exertion of effort between Tromsø 6 and 7 explained the change in health between the two waves. Further, the sample was split into two to assess whether this differed between those reporting *very difficult* or *difficult* CFC (*unfortunate* hereafter) versus those reporting *good* or *very good* CFC (*fortunate* hereafter). The fixed effects model only captures observations that change between the two waves. Hence, given the level of effort in Tromsø 6, a model estimating health with dummies for the worsening, improvement, and maintenance of effort was run on the Tromsø 7 sample as a supplementary analysis.

Oaxaca decomposition of the difference in health between the unfortunate and fortunate CFC groups was conducted, given similar level of efforts, as a supplementary analysis. This gap was decomposed into an 'explained effect'—the proportion of the gap arising from differences in the exertion of effort and demographic characteristics—and an 'unexplained effect', which captured the change in the unfortunate group's health had they experienced the fortunate group's response to the same level of exerted effort.

3 Results

3.1 Paper I

In paper I, we first aimed to generate a composite score for socioeconomic position based on a weighted combination of education and income levels. We then demonstrate its use as a predictor of HRQoL. When generating the weights for the composite SEP score, we found that for both education and income, the higher the level, the larger the contribution to the composite SEP score. While education produced the largest weights (coefficients), income indicated a nonlinear relationship with subjective SEP, as demonstrated by the weight sizes for each higher-income category. Using these weights to predict respondents' SEP based on all possible combinations of education and income levels, the nonlinearities in each level change were reinforced. For example, the predicted SEP of someone with an undergraduate degree in the upper middle-income category was five out of ten. In contrast, someone with a postgraduate degree in the same income category had a predicted SEP of eight out of ten (Table 3 in Paper I).

To generate the composite SEP score, the education and income weights were added together (Eq. (2)). Applying the composite SEP score to predict variation in HRQoL indicated a positive association existed between the SEP score and HRQoL; a one-unit increase in SEP was associated with an average increase of 0.006 for EQ-5D and 0.010 for VAS. Compared to adding education and income separately, the model fit was of a similar magnitude. To visualise how the composite SEP score predicted HRQoL, we reported a figure demonstrating the mean age-adjusted HRQoL value for each level of the composite SEP score (Figure 2 in Paper I). This indicated a linear increase in the EQ-5D and VAS mean values for each higher level of the composite SEP score, with a steeper gradient for VAS than for the EQ-5D.

Sensitivity analyses of the weights for the composite SEP score stratified by age group suggested that the importance of education (in the sense of larger weight) increased with age, whereas the opposite was true for income. Sex-stratified analyses did not yield substantially different results from the main analyses. The split-sample test generated a composite SEP score with weights from Subsample 1 to estimate health in Subsample 2. This test indicated that the coefficients remained similar, and the change in R^2 was marginal.

The hypotheses were partly confirmed. We did find that the higher the education and income level, the higher the overall SEP; however, the composite SEP score did not perform better than education and income separately in predicting HRQoL.

3.2 Paper II

Paper II aimed to estimate the relative importance of first objective SEP indicators (education, occupation, and income) and childhood circumstances, independent of objective SEP, in determining subjective SEP in adulthood. Since institutional and cultural contexts are likely to influence the relative importance of these factors as determinants of subjective SEP, we compared data from two countries: Australia and Norway. Comparing the two samples' subjective SEP scores, we found that they were significantly different overall and for all the categories of the explanatory variables, except for education. The mean subjective SEP scores were higher in the Norwegian sample than the Australian sample for all significant differences.

The main analysis consisted of three models (A-C). In Model A, education and income, adjusted for age and sex, were regressed on subjective SEP. For both samples, there was a gradually stronger association between each higher income level and subjective SEP relative to the lowest income category. Increasing educational levels were also linearly associated with subjective SEP.

Occupation was added to Model B with *other professions* as the reference category. The education and income coefficients were attenuated compared to Model A. In the Australian sample, being outside the workforce was not associated with subjective SEP (at the 5% level) relative to *other professions*. In contrast, Norwegians not in the workforce reported a significantly lower subjective SEP (corresponding to a drop of 0.7 on the MacArthur ladder). Conversely, there was a strong positive association of 0.79 with subjective SEP for *managers and professionals* in the Norwegian sample.

In Model C, childhood SEP (CFC and parents' education) were added to the model. The contribution of CFC in reporting a higher subjective SEP was significant in both samples relative to the reference (*neither good nor bad*). In the Australian sample, the better the CFC, the stronger the associations with subjective SEP, whereas those reporting (*very*) *difficult* CFC had a significantly lower reporting of subjective SEP (-0.26). In the Norwegian sample, the *difficult* CFC category was not statistically different from the reference category. On average, subjective SEP was more than one rung higher (1.18) for those with *very good* CFC. Analysis

of parents' education revealed that only the mother's education was significantly associated with subjective SEP, with an increase of 0.30 in both Australia and Norway, among respondents whose mothers had a university education. The reporting of subjective SEP increased with age in all models (Table 3 in Paper II).

Using Shapley value decomposition on the full model (Model C), we found that income and occupation were the most important determinants of subjective SEP in the Australian and Norwegian samples, respectively. Interaction and sex-stratified analyses indicated that men had an advantage in terms of a higher reported subjective SEP for income in both samples. In contrast, women seemed to benefit more from higher education in the Norwegian sample. This figure is slightly more mixed in the Australian sample. Women with a *very good* CFC reported higher subjective SEP in both samples, especially in the Norwegian sample.

Our hypothesis was therefore confirmed: childhood circumstances are significant determinants of subjective SEP, in addition to education, occupation, and income.

3.3 Paper III

In Paper III, childhood circumstances served as the socioeconomic component. The aim of Paper III was twofold. First, it aimed to estimate inequalities in HRQoL and SRH due to circumstances. Second, Paper III aimed to assess the additional impact of efforts on health inequalities by estimating how efforts affected change, maintenance, and level of health between the two waves of the Tromsø Study. Our results suggest that inequalities arise from the circumstances in both HRQoL and SRH. CFC and education are key drivers of these inequalities. Parental health also contributed substantially to HRQoL. The relative importance of the different circumstances differed considerably according to sex and age. Running these analyses across quantiles of HRQoL revealed that the inequality estimates and relative importance of circumstances differed over the distribution.

Adding efforts to the cross-sectional analysis of the Tromsø 7 sample suggested that a higher BMI, being a smoker, and being physically inactive were associated with poorer health. However, alcohol consumption showed the opposite association. Our findings indicated a limited indirect impact of circumstances flowing through efforts, except for education, which channelled some indirect influence from circumstances. Studying the role of efforts on change in health between Tromsø 6 and 7 in a fixed effects panel regression model demonstrated limited associations of effort change: only BMI ≥30 was significantly associated with a lower

HRQoL compared to the normal weight category. For SRH, the higher the BMI and the more physically inactive, the lower the probability of reporting at least *good* SRH. In a model estimating how effort change or maintenance predicts health in Tromsø 7, we found that, given the level of effort in Tromsø 6, worsening or maintaining unhealthy efforts was significantly associated with lower reporting of both health outcomes. This was not offset by a corresponding improvement in efforts, relative to those who maintained healthy efforts.

Oaxaca decomposition of the health gap between the 'unfortunate' and 'fortunate' CFC groups found that the largest share of the gap was due to the 'explained effect', reporting what the unfortunate group's health would be if this group had experienced the same 'health rewards' for the same level of effort as the fortunate group.

As hypothesised, we identified inequalities arising from circumstances. However, we found no clear indication that having a healthy lifestyle predicted improved health from a longitudinal perspective, even if the cross-sectional analyses found a positive association with healthier levels of effort.

4 Discussion

This section discusses the findings of this thesis from a broader perspective, placing it within a wider research context. Moreover, several methodological limitations require attention when interpreting the results. The following subsection addresses these limitations and methodological considerations before discussing the results.

4.1 Methodological considerations

4.1.1 Study design

This PhD project was a part of the Tracing Causes of Inequalities in Health and Wellbeing project. As its title suggests, it sought to identify causes of inequalities in adult health and wellbeing originating from childhood.

Two of the three papers in this PhD project were based on the Tromsø Study, following respondents over time and retrospectively asking participants about socioeconomic (e.g., financial conditions in childhood) and health-related factors (e.g., parental health). The SEP Survey is purely cross-sectional but contains various retrospective questions about socioeconomic conditions in childhood. This PhD project used both longitudinal and retrospective survey questions. However, most analyses are conducted using a cross-sectional design, which complicates 'tracing the causes' of inequalities.

Cross-sectional study design

Papers I-III primarily applied cross-sectional analysis. A well-known issue with cross-sectional study designs is that it is impossible to study causal relationships with observations from only one point in time because a temporal association cannot be established between exposure and outcome (180).

In Paper I, when applying the composite SEP score as a predictor of HRQoL, the primary interest was in testing the score's performance as a predictor of HRQoL, and not the causal association between them. However, it is worth noting that there could be reverse causation since healthier individuals (those reporting a higher HRQoL) could have higher education or higher income. We could have repeated the analyses using Tromsø 6 data to test the robustness of this approach. However, the cross-sectional design was not a major concern in Paper I.

In Paper II—assessing the determinants of subjective SEP—it cannot be ruled out that subjective SEP could precede some of the predictors: education, occupation, and income (e.g.,

if people have a high subjective SEP due to more prestigious jobs). However, since the subjective SEP measure is framed in terms of these socioeconomic components, it is reasonable to assume that respondents deduced their subjective SEP as a product of their education, occupation, and income. Furthermore, childhood circumstance variables are also likely to occur before the subjective assessment of individuals' SEP. However, this is not possible to control for using a cross-sectional design.

The cross-sectional analyses in Paper III assessed the importance of both circumstances and efforts (lifestyle variables). Circumstances were assumed to be constant (e.g., the reporting of CFC should not change over time) and were temporally distanced from the outcome variables (except for age). In the analyses considering circumstances only, it was reasonable to assume that the conditions proxied by the circumstance variables occurred before evaluating the respondents' HRQoL and SRH. However, we did not claim that the associations were causal. As in Paper I, HRQoL and SRH could be determinants of their education level, although we do not consider this very likely because most respondents arguably finished their education long before their current assessment of HRQoL and SRH.

Concerning the role of efforts in predicting health inequalities, there is potential for reverse causation in physical activity— healthy individuals may be more likely to be physically active (181). Therefore, we took advantage of the possibility of applying a panel design to the data.

Panel study design

To study how *change* in efforts predicted changes in health in Paper III, we applied a panel regression design: a fixed effects regression model. The advantage of a fixed-effects model is that all unobserved confounding is factored out when they remain constant over time. A fixed-effects model only considers variation within the individual (182). Therefore, this model only captures observations that change in the effort variables or the health outcomes between the two time points. Hence, those who maintain their level of effort and health do not contribute to the model. Moreover, it only reports mean change; it cannot provide information on the effect of improved versus worsened efforts on health. In principle, there might be worsening and improvement in efforts that would cancel each other out. Therefore, we ran an additional cross-sectional model including dummies for whether the individuals improved, worsened, or maintained their efforts to assess how this predicted health in Tromsø 7.

4.1.2 Bias

In study designs that rely on self-reported information, there is always a risk of bias. Therefore, it is necessary to discuss potential biases in this PhD project and how they might have influenced the results or their interpretation.

Relevant for the extent of bias and the results' generalisability is the applied exclusion criteria, as presented in Section 2.2. Therefore, a table of summary statistics of the included variables in the *full* Tromsø 7 sample is included in Appendix A.

Selection bias

Selection bias arises when the characteristics of the participants included in the study are systematically different from those of the overall population that the sample is supposed to represent. Another type of selection bias is attrition bias, which occurs if individuals who remain in a study differ systematically from those who drop out before the completion of the study (183).

Since Tromsø 4 (1994-1995), the Tromsø Study has aimed to invite representative samples of the Tromsø population, which is reflected in the sampling procedures (158). However, there is a risk the participants are not entirely representative. In general, there is a consistent finding that non-participants in population health surveys are less educated, have lower incomes (184), have worse health (185), and are more likely to be single and male (184, 186). A non-participation study of the Nord-Trøndelag Health Study—similar to the Tromsø Study, but with a lower participation rate (54 % versus 65 % in the Tromsø Study)—found that non-participants had lower SEP, higher mortality, and higher prevalence of chronic diseases (187). The extent of selection bias in the Tromsø Study has not been systematically assessed. However, the share of participants in Tromsø 6 with higher education was larger than that of both the Norwegian and the Tromsø populations (188). Considering sex and marital status, the share of women reporting to be single is considerably larger than single men (27.7 % vs 18.4 %). While the actual share of single vs married/cohabitant women and men is unknown, this could indicate that it is rather single women that are overrepresented. Therefore, there is a risk of selection bias in the Tromsø Study.

Selection bias can be addressed by adjusting for covariates that are associated with selection or by applying inverse probability weights (189). For example, since women tend to be slightly overrepresented in surveys, adjusting for sex could reduce the influence of selection bias; this

was done in all three papers. For other typical selection variables, such as education, this was already included in all the analyses as an explanatory variable.

While it is known that the sample has a higher education level than the overall population, it is not known whether the same is true for income, although this is likely in a highly educated sample. Therefore, the findings from Paper I could have overestimated the actual role of education and income in predicting SEP. Moreover, if Tromsø Study participants are healthier than the overall population, it is probable that participants reporting a high HRQoL are also overrepresented. If this is the case, the association between the composite SEP score and HRQoL could be upward biased.

In Paper III, we included only respondents who participated in both Tromsø 6 and 7, excluding more than half of the sample compared with the full Tromsø 7 sample (N ≈ 21,000 vs N ≈ 8,900). This was done to achieve a balanced panel, and to ensure comparability between the cross-sectional and panel analyses. However, this sample is arguably 'more selected' since the same nonparticipant characteristics as for selection bias are likely to occur or even be reinforced, in repeated surveys, in case of attrition bias (183). As noted in Paper III, there was a deviating distribution of responses at different education levels between Tromsø 6 and 7. Therefore, we compared the distribution of education levels in the study sample (measured in Tromsø 7) with that of the full Tromsø 7 sample. As can be seen from Table 2, the proportion of respondents with the lowest education level is considerably larger in the study sample than in the full sample and vice versa for the postgraduate level. Compared to the distribution of respondents across education levels in the Tromsø population in 2015, the share of respondents with primary and upper secondary education is overrepresented in the survey (155). Given a true reporting of education level, this suggests that people with a lower education level are overrepresented among participants in Tromsø 6 and 7, counter to expectation.

Table 2: Distribution of reported education level in the full Tromsø 7 sample compared to the study sample

	Full Tromsø 7 sample		**Paper III study sample**	
	Proportion	N	Proportion	N
Primary education <10 years	23.2	4,795	30.2	2,492
Upper secondary	27.8	5,748	28.2	2,330
Undergraduate degree	19.4	4,005	18.2	1,505
Postgraduate degree	29.7	6,143	23.3	1,923

These deviations may have influenced the results. However, when running the analysis of IOp due to circumstances (the model reported in Table 3 in Paper III), using the full Tromsø 7 sample, we did not find any large deviations in terms of education, except for a statistically significant coefficient for upper secondary education (see Table 3 below). The IOp estimates were similar, but somewhat smaller (at the second decimal place). However, the relative importance of the circumstance variables differed in some respects: for HRQoL, the contribution of parental mental health was more than twice as large, and the importance of sex was 10 percentage points lower (see Table 4 below). This aligns with a similar analysis of the full Tromsø 7 sample conducted by Berthung et al. (190). However, these results are not directly comparable because there is a slight difference in the included variables. For SRH, there were no major deviations from the original results; except for age, the relative contribution was 6.6 percentage points lower.

Table 3: *Ex ante* inequality of opportunity: Tromsø 7, full sample

	HRQoL (EQ-5D: Eng)	**SRH**
IOp estimate (SE)	0.033***[a] (0.003)	0.066***[b] (0.005)
Childhood financial circumstances (ref.: good)		
Very difficult/difficult	-0.022*** (0.002)	-0.087*** (0.008)
Very good	0.005 (0.003)	0.030** (0.012)
Own education (ref.: primary education <10 years)		
Upper secondary	0.008*** (0.002)	0.090*** (0.010)
Undergraduate degree	0.018*** (0.003)	0.155*** (0.011)
Postgraduate degree	0.029*** (0.002)	0.220*** (0.009)
Height (ref.: 60 % 'normal' height)		
20 % lowest	-0.005** (0.002)	-0.017* (0.009)
20 % tallest	0.003 (0.002)	0.006 (0.009)
Parental somatic health (ref.: 0)		
Mother: 1	-0.002 (0.002)	-0.020*** (0.007)
Mother: ≥2	-0.012*** (0.003)	-0.063*** (0.012)
Father: 1	-0.003 (0.002)	-0.024*** (0.007)
Father: ≥2	-0.013*** (0.002)	-0.050*** (0.009)
Parental mental health (ref.: no)	-0.029*** (0.003)	-0.031*** (0.011)
Parental substance abuse (ref.: no)	-0.013*** (0.003)	-0.016 (0.013)
Age groups (ref.: 40-69)		
70-79	0.006** (0.003)	-0.052*** (0.011)
≥80	-0.036*** (0.006)	-0.119*** (0.021)
Sex (ref.: women)	0.020*** (0.002)	0.001 (0.008)
Constant	0.895*** (0.002)	0.637*** (0.011)
N	*19,642*	*19,642*
R^2	*0.0488*	*0.0576*

*Note: ***p<0.01, **p<0.05, *p<0.1. HRQoL=Health-related quality of life; Eng=English value set for EQ-5D-5L; SRH=Self-rated health; IOp=Inequality of opportunity; SE=standard error. IOp estimates' SEs based on bootstrapping with 500 replications. Robust SEs in parentheses.*

[a] *IOp measure: variance*

[b] *IOp measure: dissimilarity index*

Table 4: Shapley value decomposition of the relative importance of circumstances

	HRQoL (EQ-5D: Eng)	SRH
Childhood financial circumstances	22.1 %	20.5 %
Own education	21.8 %	49.9 %
Height (age-standardised)	9.0 %	3.2 %
Mother's somatic health	3.7 %	6.5 %
Father's somatic health	3.6 %	4.3 %
Parental mental health	20.2 %	1.2 %
Parental substance abuse	3.3 %	0.4 %
Age	0.6 %	13.5 %
Sex	15.7 %	0.7 %

Note: HRQoL=Health-related quality of life; SRH=Self-rated health.

In Paper II, respondents to the SEP Survey were recruited from panel members of a panel company (www.cint.com). Therefore, there are risks of selection bias, both in terms of self-selection into the pool of panel members (191) and selection into the survey in question. Moreover, to enter an online survey such as this, individuals must have Internet access and be digitally literate, indicating that certain segments of the population might be under- or not represented (191), especially among older age groups. To arrive at the final sample, some were excluded by the panel company based on age and sex quotas to mitigate potential selection bias. Sample weights were also applied in the analyses to further reduce the influence of age and sex on self-selection among participants. However, the sample sizes were relatively small (N≈1,400 from each country), and there might have been selection bias in terms of other characteristics such as education, ethnicity, or geographical spread. Indeed, respondents with a postgraduate degree were overrepresented in both samples; similarly, those with the lowest education level were underrepresented in the Norwegian sample (192). This could have overestimated the importance of education, particularly in the Norwegian sample. Moreover, if respondents with higher education also have systematically higher subjective SEP, as Table 2 in Paper II would suggest, our results could be upwardly biased.

Measurement and recall bias

Observational studies relying on self-report and retrospective measurements of past events run the risk of measurement error. This can lead to measurement bias, also called information bias, which occurs when a systematic error arises from inaccurate measurements (183). Recall bias is one such bias, and is a measurement error that occurs as a result of '[s]ystematic error due to differences in accuracy or completeness of recall to memory of past events or experiences'

(183). Estimates of retrospective recall are biased if they vary systematically by groups, for example, by SEP. If retrospective recall is inaccurate but not systematic by health status or across groups such as SEP, it is not necessarily biased, although such measurement error could affect the study's validity (193).

There is a potential for recall bias or inaccurate recall in all the papers included in this thesis. Paper I applies only indicators that are temporally proximate or less prone to inaccurate recall. Intuitively, it seems reasonable that people can correctly recall their highest completed educational level. A validation study of the reported educational level in Tromsø 7 found that it was sufficiently accurate (194). However, in Paper III, we found relatively large differences in the reported distribution of education levels between Tromsø 6 and 7 (see Table 2 in Paper III). While this was most likely not due to recall bias, it indicates that there could be some element of measurement error or bias. This could have been influenced by the five-level categorisation of education in Tromsø 6. A transition matrix of the reporting of education between Tromsø 6 and 7 revealed that the largest share of inconsistent reporting was among those reporting vocational school in Tromsø 6, reporting primary education in Tromsø 7 (29.5 % of those reporting vocational school in Tromsø 6).

In some instances, the reporting of income is considered sensitive (195), indicating that it could be prone to measurement error or bias. This was not possible to control for without validating against the income registry of Statistics Norway through data linkage.

In Papers II and III, we used several variables that involved retrospective reporting (although measured slightly differently because they were from different data sources): CFC, parental/maternal education (Papers II and III) and parental health (Paper III). The CFC variable is framed as a subjective measure because it asks respondents to reflect on their perceived financial situation in childhood. This complicates the attempt to assess the extent of recall bias since CFC cannot be cross-validated against an objective measure. There was a somewhat inconsistent reporting of CFC between Tromsø 6 and 7, although it is unknown whether this was due to inaccurate recall. However, the reporting was relatively consistent across age groups, and the inconsistencies were mainly between the *very good* and *good* response alternatives. As mentioned in Section 2.3.3, we attempted to remedy this using coding.

Moreover, systematic differences could exist between those reporting *difficult* and *good* CFC. For example, in Paper II, those with a lower subjective SEP systematically reported a worse

CFC than those with a higher subjective SEP. This could be linked to negative affectivity, leading to measurement errors; those with more negative emotions and pessimism might report a lower subjective SEP (125). There would be recall bias if the reporting of CFC, parental education, and parental health differed systematically according to e.g., education level or income, which are common sources of recall bias (196).

The risk of inaccurate or biased recall in terms of parental exists because it might be difficult to accurately remember the duration of respondents' parental education. The parental health variables in Paper III could also be inaccurately reported depending on when the parental disease/conditions occurred. Temporal distance is a central factor in the risk of recall bias (196). Again, the main issue of recall bias is whether the responses to these questions differ systematically; for example, by SEP.

Of the included effort variables, BMI was not self-reported: height and weight were measured by a research technician. These measurements should therefore be free of reporting bias or error. Smoking, physical activity and alcohol consumption are, in contrast, all self-reported. The reporting of 'sinful' behaviours is also often underreported (197). Therefore, they are at risk of erroneous reporting.

In summary, there is a risk of measurement and recall bias in the included papers, which calls for a cautious interpretation of the results. Nonetheless, in a validation study of twins' recall of childhood SEP, Krieger et al. (107) concluded that recalling childhood circumstances (childhood social class and father's education) was sufficiently accurate for use in population health studies. This suggests that questions such as those included in the material applied in this thesis are adequate measures to obtain an impression of childhood circumstances.

Missing values

After applying the exclusion criteria specified in Section 2.2, all analyses were run as complete case analysis, including only the observations for which there were no missing values in any of the variables. This might lead to biased estimates if respondents with missing values in some of the variables are systematically different from those with complete data (198).

Using the SEP Survey in Paper II, missing values were arguably not a major issue. This was because the survey was set up such that the survey platform would remind the respondent to answer all questions if some were left unanswered before continuing with the questionnaire, thereby minimising the extent of missing values. There were no missing values for the included

explanatory variables, but N = 6 missing values for the subjective SEP variable in the Norwegian sample. We did not believe that this affected our results.

In Papers I and III, using the Tromsø Study, complete case analysis could have biased the estimates. As stated in Paper I, cases with missing values for education and income were somewhat older and had a larger share of women than in the included proportion of the sample. The reporting of HRQoL was also slightly lower. In the Paper III study sample (having excluded those with missing values in the two outcome variables), there were approximately 2.9 % and 3.2 % missing values on the circumstance variables and effort (lifestyle) variables, respectively. These are relatively low rates of missing values. However, it is still possible that the estimates were influenced or biased due to missing values.

When there are missing values in predictor variables, complete case estimates are not biased if the reasons for the missingness is unrelated to the outcome (198). However, while it is unknown why these variables are missing, we found that the reported HRQoL for the missing variables was lower in some of the predictors (see Table 5, providing an overview of the extent of missingness in predictor variables in Papers I and III). Therefore, the assumption that missingness is unrelated to the outcome might be violated.

Multiple imputation is a potential solution to missing values. Multiple imputation assumes that the data are missing at random. This means that any systematic differences between the observed and missing values can be explained by differences in other observed variables (198). However, if the data are missing not at random, i.e., the missingness is related to unmeasured factors, any bias in the complete case analyses will be as large, or even larger, with multiple imputation (198). In this case, complete case analysis would be the preferred choice (199). The only way to investigate this is through sensitivity analyses (198).

In hindsight, it would have been wise to run multiple imputation as sensitivity analyses since it is impossible to know how much the extent of missing values has influenced the results. Therefore, this is a non-negligible limitation of the two papers. However, the table with mean HRQoL (EQ-5D) scores and age for missing and observed values (given non-missing values on the health outcomes) of the predictor variables in Papers I and III, provides an indication of the extent of missingness (Table 5). Note that the parental health variables are not included in the table. This is because they were originally coded '1' if 'Yes' and unticked otherwise (coded '0' in the analyses), leaving no missing values on these variables.

Table 5: Overview of predictor variables with missing values and mean HRQoL

Variable name	Observed N (%)	Mean observed EQ-5D (SD)	Mean observed age (SD)	Missing N (%)	Mean missing EQ-5D (SD)	Mean missing age (SD)
Paper I [a]						
Subjective SEP	19,798 (97.4)	0.89 (0.11)	56.3 (10.4)	524 (2.6)	0.84 (0.15)	60.9 (11.0)
Education	20,027 (98.6)			295 (1.5)	0.89 (0.11)	64.4 (11.2)
Income	19,558 (96.2)			764 (3.8)	0.87 (0.12)	64.2 (10.5)
Paper III [b]						
Childhood financial circumstances	8,445 (99.9)	0.90 (0.11)	63.6 (11.1)	12 (0.1)	0.92 (0.14)	70.3 (5.2)
Own education	8,250 (97.6)			207 (2.5)	0.88 (0.14)	74.5 (9.4)
Height	8,433 (99.7)			24 (0.3)	0.58 (0.29)	72 (9.5)
BMI	8,425 (99.6)			32 (0.4)	0.64 (0.28)	68.4 (11.1)
Smoking	8,382 (99.1)			75 (0.9)	0.89 (0.14)	66.8 (11.7)
Physical activity	8,299 (98.1)			158 (1.9)	0.88 (0.14)	69.9 (11.2)
Alcohol consumption	8,412 (99.5)			45 (0.5)	0.84 (0.14)	74.8 (10.2)

Note: Paper I: EQ-5D Western Preference Pattern; Paper III: EQ-5D English value set. SD=standard deviation; BMI=body mass index.

[a] *Out of the Paper I study sample of N = 20,322 (respondents aged <80)*

[b] *Out of the Paper III Tromsø 7 study sample of N = 8,457*

In the Paper I study sample, the mean reported HRQoL (EQ-5D) was slightly lower or the same and the mean age was higher for those with missing values (Table 5). The observed cases could have overestimated the role of education and income if assuming that older and more unhealthy individuals are more likely to have low incomes and education levels.

In the Paper III study sample, the deviations were larger between the observed and missing observations, with generally older respondents reporting lower HRQoL (except for CFC). The reported HRQoL was particularly low for height and BMI (note that height is used in the calculation of BMI). However, there were large SDs and relatively few respondents in these estimates: the range of the EQ-5D was (0.06-1.0) for both height and BMI. This could have underestimated the extent of IOp in HRQoL, since there could be more variation in HRQoL than what is captured by the observed sample. However, it must be noted that the number of missing observations is relatively low, meaning that the mean values of HRQoL and age for those with missing values are sensitive to 'extreme' observations.

4.1.3 Validity

The extent of biases will affect a study's validity. Validity considers a measure's accuracy, determining whether the results capture what they are intended to measure (200). There are two types of validity to consider: internal and external validity.

Internal validity

Internal validity refers to whether the results are accurate for the group of people being studied (200). In Paper I, we ran split-sample analyses to test whether the main results would remain valid when applying the composite SEP score generated from one-half of the sample on estimates of HRQoL in the other half. Deviation from the main results was minimal, indicating that the results were internally valid. We did not explicitly test the internal validity in Papers II and III. However, internal validity largely depends on selection bias, confounding, and measurement bias (200). Threats to internal validity in terms of selection and measurement bias has been addressed in the previous section. The role of confounding will be addressed in section 4.1.5.

External validity

External validity, or generalisability, is the degree to which the results apply to other populations or contexts (183). The Tromsø Study constitutes the data material in Papers I and III—a general adult population aged 40 years and above (32 when considering Tromsø 6). Therefore, it is unreasonable to assume that these results are generalisable to adults below these ages.

In assessing the relative importance of socioeconomic indicators in Paper I, it was arguably advantageous to include only adults above the age of 40. This is because the applied SEP indicators are more likely to be a reliable representation of SEP when the majority have completed their education and are established in the labour market with a secure income. Because of the relatively high mean age of Norwegian students (28 years (201)) and that 25 % of students are 30 years or older (202), most people are in their thirties before they have a stable income. Therefore, it is likely that the results from Paper I, which combined education and income to predict overall SEP and, subsequently, health, are generalisable to other populations of similar age and comparable living conditions. Had we included younger cohorts, there could be more variation and uncertain patterns because people in their twenties and thirties are largely in the period in which they complete their education and find a job. There is arguably more variation at the older end of the sample, partly because the proportion of people attending higher

education has increased significantly compared to past generations. This is partly the reason for excluding respondents above the age of 80. Nonetheless, these trends are likely the same in similar populations.

The arguments regarding the measurement of education are also valid in Paper III. Concerning the other circumstance variables, we would argue that there are no apparent reasons to believe that these results should not be generalisable to similar populations. However, as discussed regarding the potential for selection bias, this sample was considerably smaller because it was restricted to participants of the two waves of the Tromsø Study, which could affect generalisability. In terms of effort variables, these results would not be generalisable if the individuals included in the sample have better lifestyles than those of comparable populations. While we did not test whether this was the case, it is a possibility that cannot be ruled out because better-educated and healthier people are more likely to participate in population health surveys (187).

The samples in Paper II, applying the SEP Survey, have a wider age span than the Tromsø Study; Paper II consists of random samples of adults above the age of 18 from Australia and Norway. In comparison, the proportion of the sample below the age of 40 was relatively large: approximately 41 % in the Australian sample and 46 % in the Norwegian sample. Consequently, the generalisability of the importance of education, occupation, and income as determinants of subjective SEP might be affected by some of the points relating to the relevance of these indicators among young adults, for whom there could be other factors that are more important determinants of subjective SEP. Moreover, the SEP Survey samples were relatively small, implying that the results are more sensitive to 'extreme' observations. With small samples covering entire countries (as opposed to a municipality), it might be complicated to estimate the general 'state' of (determinants of) subjective SEP, hampering generalisability to the populations of Australia and Norway.

4.1.4 Selection and application of variables

A short discussion of the considerations for selecting and using some of the included variables is necessary.

All three papers applied outcomes that previously have been assessed according to their reliability, i.e., the measures' consistency in reproducing the same results when applying the same test or method over time or at different occasions (183), except the subjective SEP

variable in Paper I. The Tromsø Study is the only survey in which it has been included. Therefore, its reliability is uncertain. It was inspired by Michael Marmot's work on the role of perceived status within occupational hierarchies, as documented in the Whitehall studies (25, 26, 54). The subjective SEP measure was developed to explicitly capture the subjective evaluations of occupational positions. Therefore, despite the limitation that it cannot (yet) be compared to other cohorts applying the same measure, it is still a contribution to the literature by using a theoretically grounded measure of subjective SEP. Another drawback is that it is most relevant to employed people. The question does specify that the respondents outside of the workforce are supposed to think of their previous occupation when evaluating their subjective occupational position. However, it might still influence how people respond to this question.

Both Papers I and III applied the EQ-5D. The EQ-5D is a reliable and valid instrument applicable to different populations and settings (203, 204). Considering the definitions of health presented in section 1.2.5, the EQ-5D includes dimensions of both physical function and mental health, but not about wellbeing. Since it is framed in terms of deviations from 'full health' rather than positive dimensions of health, it has been shown to have certain degrees of ceiling effects, especially in general population studies (203).

Paper I also applied a VAS. The VAS is an overall assessment of individuals' health status, and has been found to be a valid and reliable measure of health (205, 206). In Paper III, we also applied SRH as a health outcome. As with the VAS, the SRH measure is a measure of global health status, although less fine-grained than the VAS. It was included for its common use in the IOp literature, and it is widely applied in the general health inequality literature. Its reliability might be hampered by differential or inconsistent reporting by SEP (144, 207), but such inconsistencies have been found to have low impact on the measurement of health inequalities (208).

In Paper II, we applied the MacArthur Scale of SSS to reflect subjective SEP. As opposed to the subjective SEP measure applied in Paper I, the MacArthur Scale has been used in a wide range of populations and contexts (209). It has demonstrated adequate test-retest reliability (210, 211) and construct validity (131).

In Paper I, we considered including occupational category as a third component of the composite SEP score since it is a central socioeconomic dimension. As discussed in Paper I,

the reason for excluding occupation was that we assumed that its influence would be captured on the causal pathway from education to income. Moreover, the outcome variable is assumed to capture parts of the occupational dimension. Including occupation would exclude the respondents who reported that they were not currently part of the workforce. Consequently, the sample size would decrease substantially (to N≈13,000) because of the number of missing values (people outside the workforce). In analyses that were not included in the paper, we found that the composite SEP score, including occupation, performed worse in predicting HRQoL (EQ-5D and VAS), both in terms of coefficient size and model fit, R^2. Nevertheless, we acknowledge the theoretical argument of including occupation in such a composite score, given the fact that these three SEP indicators are the most common and that the occupational dimension might not be fully captured in the final composite SEP score.

In Paper II, we included the predictor variables in a stepwise manner. There is already literature on the role of the three objective SEP indicators as predictors of subjective SEP that the MacArthur Scale is based on (e.g., Singh-Manoux et al. (124) and Andersson (175)). Our contribution was to add the childhood SEP variables as predictors. We hypothesised that these variables could proxy a 'silver spoon effect'. That is, people born into favourable socioeconomic circumstances were more likely to report higher subjective SEP. We found that childhood financial circumstances were an appropriate variable to capture the importance of childhood SEP. The influence from parental education was limited, and we found that out of the two parental education variables, it was mother's education that was the most important.

Paper III follows the inequality of opportunity (IOp) framework, grouping variables into circumstances and efforts. Although this is termed a framework, it does not mean that there are clear 'guidelines' on selecting and classifying variables, which depend on normative judgments and theoretical positions (as well as data availability). Therefore, there is a need to justify further some of the choices made.

There is controversy in the IOp literature on how to classify education. We followed the strand classifying education as a circumstance (see e.g., Rosa Dias (212)). This was because parental and socioenvironmental factors heavily influence cognitive ability, social development in childhood and adolescence, and educational outcomes (212). The IOp framework distinguishes between circumstances and efforts based on individual responsibility in that the individual can only be held responsible for factors inside the individual's control. Carrieri and Jones (213) justify classifying education as a circumstance variable based on the UK's age of responsibility,

which is 18. Most schooling takes place before age 18 and lays the foundation for further educational attainment. We argued that this is also true in the Norwegian context. Nonetheless, it is important to recognise that others (e.g., Rosa Dias (67)) classify education as an effort variable. This could have been considered in Paper III since there is undoubtedly an element of individual choice in education, and the temporality of education differs from the other circumstances, which are 'established' early in life. As can be seen from Figure 1 in Paper III, estimated IOp would be significantly reduced if education had been classified as effort, especially for SRH.

While an association between parental health and current HRQoL or SRH could indicate intergenerational transmission of health, the included health variables from the parent generation are quite different. Ideally, one would study the same health outcome in the parent and offspring generations to classify it as 'pure' intergenerational transmission of health. Nonetheless, we believed that these findings contribute to understanding how various health conditions in parents can influence their children's health, which also justifies analysing parental health as circumstances. However, it should be noted that we do not know the timing of these health conditions, whether they occurred during the respondents' childhood or whether they occurred well into their adulthood. In the majority of cases, the latter might be the most likely, which could legitimately question the usefulness of these variables. For example, it may be asked whether angina in an asthmatic parent significantly influences their offspring's health. This could explain the modest contribution of parental somatic health. The parental somatic health variable is also unspecific as it combines seven different health conditions of varying severities (e.g., asthma vs stroke).

Age and sex were also analysed as circumstances because they are factors entirely outside the control of the individual. Moreover, discrimination based on age and sex (gender) is illegitimate and prohibited according to the Norwegian Equality and Anti-Discrimination Act (214), corroborating the classification of these factors as circumstances, as in Carrieri et al. (215). In other studies applying the IOp framework, ethnicity is included as a circumstance (179); it is a factor for which the individual cannot be held responsible. It can, therefore, be argued that inequalities based on age and sex are just as unfair and that they should be targeted by policy. However, some studies considered age and sex as demographic controls (106), for which there may be good reasons. Especially in terms of age, it could be argued that it is not 'unfair' to have declining health as people age. Nonetheless, there might be a differential impact of SEP on health across age groups (121), which supports the inclusion of age as a circumstance. When it

comes to sex, there is evidence suggesting that parts of the sex differences in health are socially derived (118), even if it is a biological determinant of health. Some of the sex (gender) gap can also be explained by behaviour: Schünemann et al. (120) found that up to 89 % of the observed gap between men and women could be ascribed to different behaviours. An advantage of the Shapley decomposition analyses conducted in Paper III is that it is possible to tease out the influence from age and sex in estimating IOp in health.

Alcohol consumption was measured using a question regarding frequency. We considered combining this with a measure of quantity in units, as this is another question included in the Tromsø Study. However, we decided to keep only the frequency question for simplicity because we considered quantity to be more prone to erroneous reporting than frequency. Nevertheless, we acknowledge that our estimates of alcohol consumption are imperfect. However, since this was one of several effort variables, we were more concerned about efforts as a whole rather than separate associations.

4.1.5 Statistical considerations

Considerations regarding the choice of statistical models will be discussed in this section, followed by reflections on the role of confounding as this is relevant to the choice of models.

In Paper I, we applied ACLR to generate a composite SEP score. We could have considered methods that were not regression-based to generate the composite SEP score to avoid the need for an outcome variable in generating the score, such as principal component analysis. However, this would have excluded the subjective component, which we regarded as a strength. Furthermore, we analysed HRQoL using OLS regression. The EQ-5D distribution was skewed to the left due to the EQ-5D's ceiling effect. Therefore, OLS might not have been the best way to fit such a model. We could have considered running a quantile regression model, as in the sensitivity analyses in Paper III, to assess whether the composite SEP score would predict the EQ-5D index value differently across the distribution.

In Papers II and III, we included (childhood) circumstance variables, in addition to adult SEP variables, to estimate subjective SEP (Paper II), and HRQoL and SRH (Paper III) in adulthood. Given that these circumstance variables refer to past events/conditions, mediation models could have been an alternative. This would be in line with the literature that estimates the mediating role of some adult SEP indicator in the association between childhood circumstances and health, e.g., Sheikh et al. (216), who studied the role of education as mediating the association

between childhood SEP and adult health. In Paper II, we estimated the joint association of childhood circumstances and objective, adult SEP with subjective SEP; this only reported the direct association between these predictors and the outcome. It would undoubtedly be interesting to analyse the *indirect* association of childhood SEP flowing through adult objective SEP, on subjective SEP, since it is known that childhood factors influence adult socioeconomic outcomes (103). In the model in Paper II (Table 3), the indirect association could only be evaluated through how the objective SEP coefficients differed before and after adding childhood circumstance variables.

In Paper III, we could also have considered running a mediation model to estimate the direct, indirect, and total influence of circumstances running through efforts, which would have provided a valuable contribution to the story. Moreover, given the ambiguities regarding the role of own education (i.e., it could be considered as an effort variable), it would have been valuable to assess whether it mediated the association between childhood conditions and health. Sheikh et al. (216), used Tromsø 6 data to identify a strong, direct effect of CFC, independent of own education, on various health outcomes, including the EQ-5D and SRH. Moreover, they found that the influence of parental education was mainly indirect and mediated by education. We did consider conducting mediation analyses estimating the role of efforts as mediators but were unsuccessful in fitting a model that was able to accommodate the need to combine different types of models because of the different variable types (continuous and categorical variables). Moreover, due to the number of circumstance and effort variables, with a consequently large number of direct, indirect, and total paths to estimate, we did not find interpreting and communicating the results practical. Therefore, we opted for a simpler, although less precise, option of adjusting for circumstances in an OLS model estimating efforts as predictors of health, as included in the supplementary analyses.

In the panel analyses in Paper III, the HRQoL measured at Tromsø 7 (EQ-5D-5L) was modified using the crosswalk version, which applied the 3L UK value set on the 5L version, as specified in Section 2.3.3. This means that there are only three severity levels, which have shown an increased risk of ceiling effects (217). The 3L UK value set was based on a survey conducted in 1993 (165). These limitations should be considered when interpreting the results.

Lastly, in Paper III, where we used data from two time points, we could arguably have taken more advantage of the time dimension. Although it was only two time points, it would have been valuable to further explore the potential of having panel data.

The role of confounding

Confounding occurs when a third variable partly or fully explains an association between an exposure variable and the outcome variable; the third variable is associated with both the explanatory and outcome variables but unaffected by exposure (183). In the analyses of the three papers, we used models with several exposure variables since we were interested in the joint contribution or association of the included variables.

Confounding in an observational study can be remedied by stratification on the confounder variable, adjustment, or matching (183). In terms of adjustment, all analyses included age and sex as potential confounders (although these were considered explanatory variables in parts of the analyses in Paper III) based on literature on their association with health (118, 121) and subjective SEP (124). Other predictor variables could be considered as confounders, such as SEP indicators. However, based on the discussion about the potential to conduct mediation analysis, this would preclude considering adult SEP indicators as confounders because they are factors that are on the causal pathway between the exposure (here: childhood circumstances) and the outcome (subjective SEP or health); the exposure or outcome cannot affect a confounding factor (200). Therefore, it seems sensible to only adjust for age and sex since these factors are not influenced by any predictors or outcomes. The same applies when only adult SEP (education, occupation, and income) is considered.

Considering stratification, we added analyses stratified by sex and age groups in Papers I and III and sex-stratified analyses in Paper II as supplementary analyses. As discussed in the separate papers, this revealed some evident differences between women and men and across age groups. We did not consider matching.

There is a risk of unmeasured, or residual, confounding. This can be defined as leftover confounding after having adjusted for 'wrong' or inadequate confounders (183). This would occur if there were other confounders that was not included in the analyses. It is impossible to rule out the presence of residual confounding in these analyses.

4.2 Discussion of main results

The main aims of this thesis were to explore different ways of measuring social position to identify social inequalities in health. The focus was on objective, subjective, and childhood circumstances; and to assess the added impact of lifestyle. We found that a composite SEP score generated from weighted combinations of education and income levels predicted the

overall SEP nonlinearly, adding insights into the combined influence of education and income. The composite SEP score performed similarly in predicting HRQoL as education and income separately. Moreover, childhood circumstances contributed significantly to estimating subjective SEP, independent of objective SEP indicators, in the Australian and Norwegian samples. Income was the most important determinant of subjective SEP in Australia, while in Norway, it was occupation. Furthermore, we identified inequalities in opportunity in HRQoL and SRH arising from circumstances, although with slightly different estimates for the two health outcomes. Adding lifestyles to the model contributed significantly to estimated inequalities, although *change* in lifestyles had mixed results on health improvement: it was rather worsened lifestyles that seemed to impact health negatively. It was primarily the 'fortunate' ones that were able to benefit from committing to behaviour change.

These results have been discussed in detail in the three included papers. Therefore, this discussion focuses on the golden thread between the papers and places the results in a broader context.

4.2.1 The socioeconomic component of health

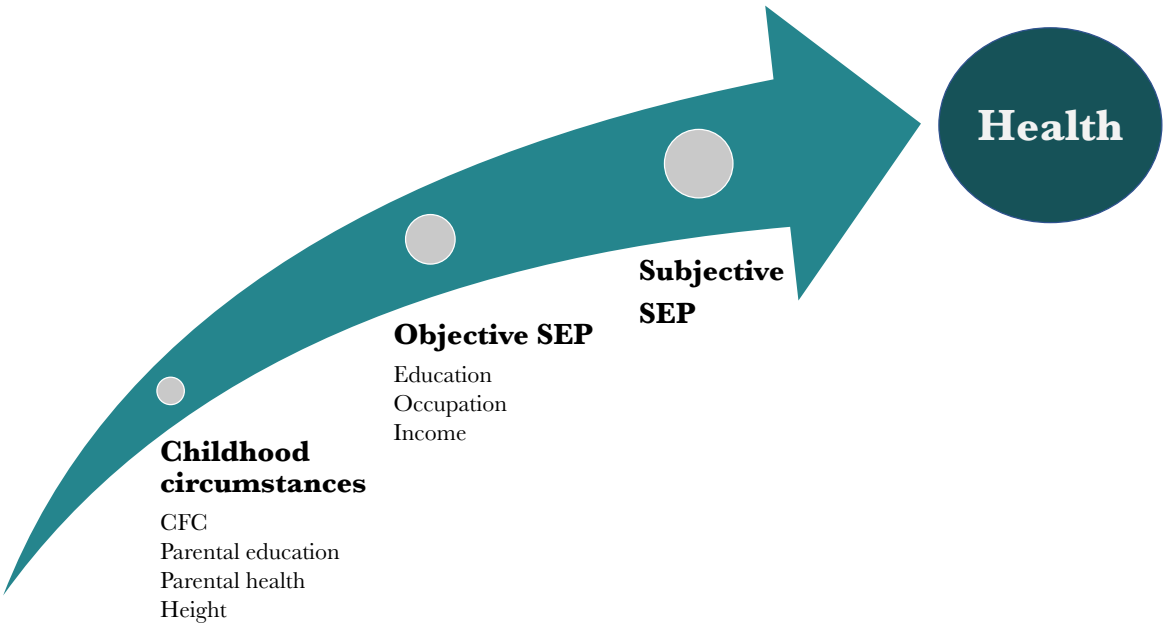

Figure 2: Overview of the socioeconomic component of the included papers.
CFC=childhood financial circumstances; SEP=socioeconomic position.

Figure 2 presents the different socioeconomic indicators considered in this thesis and seeks to clarify their relationships and their hypothesised relationship with health. The arrow indicates the temporality of the different variables: childhood circumstances inevitably come first,

influencing adults' objective SEP. Subjective SEP is hypothesised to be determined by both childhood circumstances and objective SEP. These socioeconomic determinants are hypothesised to predict adult health status, although we acknowledge the potential for reverse causation and other associations.

Objective SEP: Education, occupation, and income

All the papers in this thesis investigated the role of objective SEP in predicting subjective SEP (Papers I and II) and health (Papers I and III). In Paper I, we showed how combinations of education and income levels predicted overall SEP with large jumps on the 1-10 composite SEP score, especially for education. The predicted SEP was relatively high with high levels of education, regardless of income category. In contrast, the influence on predicted SEP was reinforced at higher education *and* income levels (Table 3 in Paper I). This is arguably not surprising since higher education is associated with higher income. Although not directly comparable, similar nonlinearities were reported by Andersson (175), who found that the relationship between education, occupation, income, and subjective SEP measured by the MacArthur Scale took a quartic form; there was a sharp increase at the bottom and upper middle of the ladder, but with a steep drop between the two highest rungs. These identified non-linearities in the relationship between objective and subjective SEP demonstrate the value of using data-generated weights, rather than *a priori* defined weights or unweighted combinations of components, in creating a composite SEP score.

The motivation behind the composite SEP score was to combine two key indicators of objective SEP that would capture the construct of SEP, potentially better than separate SEP indicators, as some studies suggest (117). However, the resulting composite SEP score proved to have little added value in predicting HRQoL, with similar model fits compared with analysing education or income separately. Nonetheless, we maintained that the SEP score added value in communicating how education and income combined predicted HRQoL and demonstrated a steady, gradual increase in HRQoL for each higher value of the SEP score (Fig. 2 in Paper I). The gap from the bottom to the top was steeper for VAS than for the EQ-5D, which could indicate that the VAS, as a direct measure of overall health status ranging from [0-100], is more sensitive to variation in subjective assessments of health status than the indirect EQ-5D, which describes health over five specific dimensions.

In Paper II, we applied education, occupation, and income as determinants of subjective SEP. The MacArthur Scale is formulated in terms of these three socioeconomic indicators,

suggesting that they are important determinants of subjective SEP. Our results confirmed this finding, consistent with the literature. For example, Singh-Manoux et al. (124) found that respondents primarily used these socioeconomic criteria as determinants of subjective SEP, in addition to satisfaction with standard of living and feeling of future financial security.

Although the predictors applied in Paper III are not termed objective SEP (they are framed as circumstance variables), some would still be characterised as such: education, maternal education, and, to a certain extent, CFC. However, the latter indicator can be argued to be more subjective since respondents will answer based on perceived childhood conditions. The impact of these indicators will be discussed from the perspective of childhood circumstances. Nevertheless, it is worth mentioning that education contributed substantially to the estimated inequality in both HRQoL and SRH at 19 % and 47 %, respectively. Education was also the main channel through which circumstances indirectly influenced effort (lifestyle) variables, corroborating the results found in Paper I, as well as the general finding in the literature that education is a strong predictor of health, e.g., Conti et al. (83) and Steingrímsdóttir et al. (218).

The focus on the most common objective SEP indicators—education, occupation, and income—in estimating social inequalities in health are largely in line with the materialist explanation (219), focusing on differences in access to health-enhancing resources. Income is arguably the indicator that most directly reflects material resources; however, occupation and education are also a proxy for material resources through their role in the differential accumulation of material exposures (72, 220). Paper I, therefore, focuses the most on the materialist perspective, although with a psychosocial component (subjective SEP). Paper II aligns more with the psychosocial approach, even if applying typical 'material' indicators to determine subjective SEP.

The role of subjective SEP

We applied subjective measures of SEP in Papers I and II. In Paper I, subjective SEP was applied as a proxy for overall SEP using education and income to estimate weights representing the relative contribution of these factors to the concept of SEP. As such, we combined both objective and subjective SEP measures. Paper I did not explicitly explore how subjective SEP predicted health; it was only indirectly included in the estimation of the composite SEP score.

It was primarily in Paper II that subjective SEP played the main role. The literature on how subjective SEP predicts various health outcomes, either independently or compared to objective

SEP indicators, is vast (55, 56, 125-127). However, the number of studies investigating the determinants of subjective SEP is not as prolific, although there are exceptions (124, 175). Andersson (175) assessed how objective SEP indicators would best predict subjective SEP and identify non-linearities in the distance between the rungs of the MacArthur ladder.

Paper II used samples from Australia and Norway. We found that income was the most important determinant of subjective SEP in the Australian sample. Respondents in the highest income category had a subjective SEP of almost two rungs higher than those in the lowest income category. As discussed in Paper II, we speculated that the importance of income in Australia could be due to the relatively larger income inequalities measured by the Gini index. Moreover, we mentioned how the private sector is more pronounced in delivering welfare services (e.g., private schools, private health insurance), which can create a status division between those who can afford these status-enhancing services and those who cannot. For example, it has been found that people attending private schools in Australia were more likely to proceed with a university education than those attending public schools (221). Additionally, tuition fees for higher education are among the highest in the OECD (222). This could indicate that income plays a larger role in the education system in Australia than in Norway, which is likely to influence subjective SEP.

In the Norwegian sample, occupation contributed the most to determine subjective SEP. Compared to what we termed the *other professions* category, those outside the workforce reported a subjective SEP that was almost one rung lower. Conversely, respondents in the *managers and professionals* category was 0.6 higher. The negative association of being outside the workforce led us to speculate that the dominant workfare policy that governments have maintained across the political spectrum ('arbeidslinja') could negatively impact those outside the labour force. This policy aims to keep as many people as possible in employment and there are well-established mechanisms to support people in (re-)entering the labour force rather than being passive cash benefit recipients. Therefore, the mantra of this policy is that it should pay off to work (223). However, for some who nevertheless are unable to work, the size of the welfare benefit payments might be too low to make ends meet. Since these payments are set at a lower rate than individuals' former salary (224), they might not cover the actual costs of living. The contrast to those with managerial and professional positions, a group with continuously increasing salaries (225), becomes forbidding. Intuitively, this is likely to negatively influence how people perceive their positions in society, as well as their health (226). Nevertheless, exploring how these issues influenced health was beyond the scope of this study.

Investigating subjective SEP follows the psychosocial explanatory model, emphasising how inequality and the feeling of inferiority/superiority trigger various stress mechanisms and, therefore, 'gets under the skin', influencing health outcomes (46). A central contribution to this literature is *The Spirit Level* by Wilkinson and Pickett (58), who argued that the three most important markers of psychosocial stress are low status, lack of friends, and a difficult early childhood. We have not investigated the role of social relationships, but the factors discussed seem to negatively influence perceived status and, therefore, psychosocial stress. The role of childhood factors is discussed in the next section.

The role of childhood circumstances

Both Papers II and III analysed childhood circumstances, although with different applications. Paper II investigated the added contribution of CFC and parental education (in addition to education, occupation, and income) as determinants of subjective SEP. Here, we found that, although the largest share of explained variance in both samples was accounted for by objective SEP, childhood circumstances contributed to approximately one-fifth of explained variation (21 % and 18 % in Australia and Norway, respectively). It was only in the Australian sample that reporting (*very*) *difficult* CFC was significantly different from the reference (*neither good nor bad*), suggesting that adverse childhood circumstances could have a larger detrimental impact on subjective SEP in adulthood in Australia than in Norway (e.g., Kendig et al. (227) on the impact of childhood adversities on adult wellbeing in Australia). Reports of *very good* CFC were associated with a subjective SEP of more than one rung higher than the reference in the Norwegian sample. While this was also a positive association in the Australian sample (0.7), the jump from *good* (0.4) to *very good* (1.2) among Norwegian respondents could point to a 'silver spoon effect' on subjective SEP; being born into fortunate circumstances was a status-enhancing privilege that persisted into adulthood.

This is an important contribution to the literature, as the role of childhood circumstances as a determinant of subjective SEP has only to a limited extent been studied, to the best of our knowledge. Ferreira et al. (228) and Kim and Radoias (229) investigated the role of childhood circumstances on subjective SEP, but they were from two relatively different contexts: Brazil and Indonesia, respectively. Therefore, we believe that the findings in Paper II are an important contribution to the literature as they provide insights from high-income settings. Nonetheless, it should be mentioned that the literature investigating subjective SEP as a measure of past, present, and future evaluations of own social position (according to the 'cognitive averaging'

principle) recognises subjective SEP as being partly a product of early-life conditions (127, 230). However, these studies do not explicitly estimate how childhood circumstances predict subjective SEP.

In Paper III, childhood circumstances were conceptualised slightly differently from those in Paper II. In line with the IOp approach, we defined circumstances as factors that are beyond the control of the individual. The set of included variables was larger, as discussed in Section 4.1.4.

As in Paper II, we conducted decomposition analyses of the relative contributions of the different circumstance variables in determining HRQoL and SRH. For both outcomes, it was primarily CFC and (own) education of the 'socially derived' circumstance variables that had the largest contribution. The influence of CFC highlights and reaffirms the existence of a 'long arm' of childhood conditions on health outcomes into adulthood (61). As mentioned in Paper III, it was mainly those reporting (*very*) *difficult* CFC, compared to *good*, who contributed to this picture, with no or limited influence from reporting *very good* CFC. This suggests that policymakers should prioritise early life interventions, creating a foundation for good life chances to fulfil people's opportunities to live in good health.

Education is a central component in creating life chances for children, and it is viewed as an institution with the potential to level the playing field, equalising opportunities for children (231). As such, a system with universal access to all levels of education without tuition fees, as in Norway, should warrant small inequalities. Nevertheless, we found that both in terms of subjective SEP (Paper II) and health (HRQoL and SRH, Paper III), there were clear indications of an education gradient. The education gradient in subjective SEP was steeper in Norway than in Australia.

Parents' health is often transmitted to their children, partly due to genetics and partly due to social mechanisms and behaviour (104, 232, 233). We found that there was a significantly lower reporting of health for those having a parent with multimorbidity (at least two somatic diseases/conditions). The same was found for mental health problems, whereas substance abuse was significant only for HRQoL. The combined contribution of the parental health variables was 19 % for HRQoL and 8 % for SRH (as a share of explained variance), suggesting that there is a stronger element of intergenerational transmission of health (104) in HRQoL. Parental somatic health and parental mental health were the strongest components of these three. Somatic and mental health are elements captured in the EQ-5D, which could partly explain why

HRQoL had a larger contribution from these factors than the single-item SRH measure. However, we did not verify this, and a range of other factors could influence these findings.

The biological determinants of health (with social dimensions), age, and sex, also contributed to the estimated IOp: mainly sex for HRQoL and age for SRH. It is not uncommon or surprising that these factors contribute substantially to such estimates (234). However, it can still be discussed how *unfair* it is for an 85-year-old to have poorer health than a 45-year-old. The question is whether 85-year-olds with higher SEP are in better health than 85-year-olds with low SEP. In this case, age-related inequalities in health would be unfair because they differ by socioeconomic condition. Investigating this through interaction analyses of age and sex would have been an option. In terms of policy, however, it all comes down to prioritisation. Given the ambiguities concerning these factors, policymakers should target early life interventions, as our results on the socially determined circumstances, such as CFC, would suggest.

Regarding policies targeting early life circumstances, the focus is on universal programmes in Nordic countries, such as free maternal and child health services, child benefits, and subsidised day-care (235). This contrasts with countries such as the UK and US, where programs targeting low-income families or people living in deprived areas are more common (235, 236). In Norway, universal programmes such as those mentioned above have been successful and cost-effective: universal maternity and infant care have contributed to large drops in infant mortality (235) and subsidised day-care has had a positive effect on educational attainment, labour market participation and reduced welfare dependency (237). However, there are still efforts to be made in reducing inequality, as pointed out in Section 1.1.1. Arntzen et al. (42) proposed a range of recommendations for reducing health inequalities in Norway, some of which concerned childhood and adolescence. These included raising child benefits; increasing funding and ensuring the competent staffing of child health centres and school health services; further facilitating day-care enrolment; strengthening social skills in schools; flexible curricula and practical tasks in schools; and introducing free and healthy school meals.

Investigating the role of childhood circumstances is in line with the life course perspective. However, since the included early-life variables are entirely based on retrospective recall, these models do not qualify as actual life-course models. They still attempt to capture the impact of early life circumstances on outcomes in adulthood. Additionally, Paper III applied the inequality of opportunity approach.

4.2.2 The added influence of lifestyle factors (efforts)

It was only in Paper III that lifestyle factors were included. The motivation for the inclusion of lifestyle variables, in contrast to Papers I and II, is based on the IOp theory and literature, in which inequalities attributable to lifestyles (efforts) are contrasted with inequalities arising from circumstances.

In cross-sectional analyses, efforts were significantly associated with health: the healthier the behaviour, the stronger the association with health. The exception to this was alcohol, for which higher consumption was associated with improved health, consistent with the literature on positive associations between a light to moderate alcohol consumption and HRQoL and SRH (e.g., Kim and Kim (238); Gémes et al. (239)). Moreover, concerning circumstances, only education channelled an indirect influence of circumstances via efforts on health, suggesting that the overall influence of circumstances was primarily a direct one.

In panel analyses, we found limited indications of healthy behaviours leading to improvements in health. Rather, *worsened* efforts between Tromsø 6 and 7 had a significantly negative influence on health. The analyses splitting the sample according to those reporting (*very*) *difficult* and (*very*) *good* CFC ('unfortunate' vs 'fortunate') indicated that for the unfortunate group, committing to healthier behaviours did not make much of a difference, while for the fortunate group, there was health to lose from unhealthy behaviour. Had we applied the unhealthiest effort category as the reference in the analyses, this figure would be flipped: there would be health to gain for the fortunate group. If the fortunate ones have higher education than the unfortunate group, this could partly explain why education had an indirect effect via effort: those with higher education could be more 'efficient' in translating behavioural change into health improvements (240).

This could indicate that a narrow focus on individualistic and behavioural strategies to reduce inequalities in health (via health-related behaviours) are less effective, potentially because they fail to consider the complex, structural, and social dynamics underlying health inequalities (241). Indeed, such approaches have often been deemed ineffective in reducing health inequalities or even exacerbating them (241). This can partly be explained by a tendency by which it is primarily those with the socioeconomic resources to commit to behaviour change that benefit from such initiatives (in this case, the fortunate group). Moreover, these strategies are inadequate in targeting the factors causing the skewed distribution of bad health behaviours and ill-health (29, 242, 243).

In addition to a central role in the IOp framework, the focus on the role of lifestyle factors is in line with the cultural-behaviour approach, primarily targeting individual factors and responsibility in explaining health inequalities. The IOp framework states that individuals should be held (partly) responsible for inequalities arising from efforts since they are within the individual's control (67). The common denominator with the behavioural approach is the role of individual responsibility. They differ in whether this is a task for policy to solve: while the behavioural approach implicitly focuses on policies facilitating healthier individual behaviours, the IOp framework asserts that it is inequalities arising from *circumstances* that must be targeted by policy. Inequalities arising from efforts are deemed 'legitimate' because they arise from individual preferences and choices and should not be of concern to policymakers. IOp acknowledges the role of the social determinants of health arising from differences in circumstances while holding individuals responsible for their own choices and behaviour. However, by intervening on the upstream factors that cause inequalities arising from differences in efforts, there is an indirect route from which efforts will be targeted, as they are assumed to be partially determined by social background.

5 Conclusions

This thesis presents and discusses the results of three papers with different theoretical foundations but with a central overarching topic: measuring socioeconomic position to identify social inequalities in health and the added impact of lifestyle.

We found that combining education and income levels as determinants of overall SEP led to nonlinear, reinforced impacts with higher education and income levels. The composite SEP score did not perform better than analysing education or income separately and cannot be warranted as a substitution for separate SEP indicators. Concerning determinants of subjective SEP, we found that while objective SEP were important determinants in both Australia and Norway, childhood circumstances played a substantial role in predicting subjective SEP. Lastly, we identified inequalities in health attributable to circumstances in the Tromsø Study, from which childhood financial circumstances and education were the main determinants. There was also a significant contribution from parental health. From a cross-sectional perspective, a healthy lifestyle was positively and significantly associated with health. However, longitudinally, the worsening of lifestyle predicted worsened health. The results indicated that individuals from fortunate socioeconomic backgrounds have more to lose from a worsened lifestyle than those from unfortunate backgrounds, for whom healthy behaviours did not make a significant difference.

In conclusion, we found that the objective, subjective, and childhood dimensions of SEP were key in identifying social inequalities in health. This encourages a comprehensive approach to the measurement of SEP, by also considering measures other than the most common indicators.

5.1 Contributions, implications, and future perspectives

This thesis has contributed with insights primarily from a high-income, egalitarian context with comprehensive and generous welfare policies, on the measurement of social position in identifying social inequalities in health. It highlighted the importance of capturing several SEP dimensions, as demonstrated through the synergistic combination of education and income into a composite SEP score, reporting on a nonlinear relationship between education and income and their relative importance as determinants of SEP. Moreover, this thesis has identified and compared the relative contribution of the determinants of subjective SEP in two different high-income countries. It has demonstrated the importance of not only the three 'classic' SEP indicators but also childhood circumstances as determinants of subjective SEP. This suggested

a silver spoon effect of being born into fortunate conditions with lasting impacts into adulthood. Lastly, the thesis provides insights into inequalities of opportunities in health, with a considerable contribution from childhood and parental characteristics, and the role played by lifestyle in an egalitarian setting like Norway.

Future research assessing the role of SEP in studies of social inequalities in health should clearly motivate the choice of SEP variables based on hypothesised mechanisms in their relationship with health outcomes. This is necessary to avoid the arbitrary use of SEP variables, increase transparency, and facilitate comparability across studies. Although the composite SEP score generated in Paper I was not superior to the inclusion of separate SEP predictors, this approach should be further tested and applied using other data materials, in other contexts, and for other health outcomes. Including a suitable indicator of occupation should also be explored. Moreover, Paper II demonstrated the value of investigating and comparing the determinants of subjective SEP between two countries. This should be expanded to delve further into cross-country differences and similarities. It would also be valuable to have observations from several time points to assess trends over time. Given the importance of childhood circumstances, their role as determinants of health mediated by subjective SEP should be explored. Furthermore, in Paper III, the role of childhood circumstances was substantial for health, indicating that there is a large potential to investigate other factors. Using other data sources or linking to registries to retrieve more early life information, such as parental characteristics, would enrich these findings. Exploring other mechanisms between early life factors as determinants of adult SEP and health status would be valuable. Moreover, the extent of intergenerational transmission of parental characteristics and parental health should also be examined. In assessing the added influence of lifestyle, the included variables captured a limited portion of this dimension. Future research should apply additional lifestyle variables, e.g., on diet, and to the extent possible, include objectively collected measurements.

There are important policy implications following from this PhD project. As highlighted in Papers II and III, it seems evident that policymakers should prioritise early life interventions and initiatives and further improve existing programmes that have proven effective (such as child benefits). Moreover, policies should move away from individualistic approaches without considering the underlying socioeconomic context. A particular challenge in Norway in designing suitable policies is that many recommendations from the literature on intervening on the upstream social determinants of health (46) are already, to a certain extent, in place. This might dampen policymakers' interest in introducing or improving other policies. Nonetheless,

the *will* to implement such policies has not always resulted in adequate execution, as documented after the 2007 government strategy to reduce social inequalities in health (41). Another challenge is that many of these policies have been found to favour the well-off in society (244), thus increasing inequalities. Moreover, the unintentional widening of inequality is even more prevalent regarding the effects of purely behavioural interventions. It has been repeatedly documented that it is primarily the already healthy and wealthy who benefit from such programmes (241). We found limited evidence of health improvement due to healthy lifestyles, in which the 'unfortunate' group seemed to remain unaffected. Jointly, this points to the need to primarily focus on the underlying social and structural context in designing policies to reduce social inequalities in health.

In terms of the psychosocial aspect of health inequalities, one of the critiques of this explanatory model, is that it leaves limited room to translate these factors into policies aimed at reducing health inequalities, distorting the importance of underlying material causes of inequalities (220). However, this perspective disregards the fact that psychosocial aspects influence quality of life and somatic disease (128). The psychosocial perspective can be useful in understanding how social structures influence psychosocial dimensions. These can be translated into policies by targeting, for example, working conditions and job control (128), which have been documented as important predictors of health (54, 245). Although we did not investigate how subjective SEP relates to health in Paper II, our findings indicate a potential to introduce policies targeting income inequalities, social inclusion policies, and childhood circumstances in which people grow up.

Finally, this thesis has shed light on the applications of different socioeconomic indicators in the context of inequalities in health. Its findings support the literature on social inequalities in health advocating for policies focusing on the population rather than the individual, taking a broad rather than a narrow diagnosis- or group-specific perspective. It recognises health as influenced by large, structural processes reaching far beyond the health sector, calling for a need to consider impacts on health inequalities of *all* policy- and decision-making (2).

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Paper I

Lindberg MH, Chen G, Olsen JA, Abelsen B.

Combining education and income into a socioeconomic position score for use in studies of health inequalities.

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RESEARCH

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Combining education and income into a socioeconomic position score for use in studies of health inequalities

Marie Hella Lindberg[1*], Gang Chen[2], Jan Abel Olsen[1,2,3] and Birgit Abelsen[1]

Abstract

Background: In studies of social inequalities in health, there is no consensus on the best measure of socioeconomic position (SEP). Moreover, subjective indicators are increasingly used to measure SEP. The aim of this paper was to develop a composite score for SEP based on weighted combinations of education and income in estimating subjective SEP, and examine how this score performs in predicting inequalities in health-related quality of life (HRQoL).

Methods: We used data from a comprehensive health survey from Northern Norway, conducted in 2015/16 ($N = 21,083$). A composite SEP score was developed using adjacent-category logistic regression of subjective SEP as a function of four education and four household income levels. Weights were derived based on these indicators' coefficients in explaining variations in respondents' subjective SEP. The composite SEP score was further applied to predict inequalities in HRQoL, measured by the EQ-5D and a visual analogue scale.

Results: Education seemed to influence SEP the most, while income added weight primarily for the highest income category. The weights demonstrated clear non-linearities, with large jumps from the middle to the higher SEP score levels. Analyses of the composite SEP score indicated a clear social gradient in both HRQoL measures.

Conclusions: We provide new insights into the relative contribution of education and income as sources of SEP, both separately and in combination. Combining education and income into a composite SEP score produces more comprehensive estimates of the social gradient in health. A similar approach can be applied in any cohort study that includes education and income data.

Keywords: Socioeconomic position, Socioeconomic status, Health inequalities, Health-related quality of life, Composite indicator

Background

An extensive empirical literature has documented a positive association between individuals' socioeconomic position (SEP) and their health, commonly referred to as the social gradient in health [1, 2]. The social gradient reflects that individuals' structural location in society is an important determinant of the likelihood of experiencing health-damaging exposures, or of holding certain health-enhancing resources [3]. This is largely built on the theoretical contribution of Max Weber, who argued that society is stratified into hierarchies along various dimensions, creating groups based on different sets of skills, knowledge, and assets. These factors, which Weber defined as individuals' "life chances", produce social stratification and will, as such, determine individuals' position in the marketplace [4]. Measures of SEP aim to reflect these life chances [5].

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However, there is no single measure that best identifies SEP [4]. Therefore, SEP is most commonly captured by three proxy measures: education, occupation and/or income [6]. Through various mechanisms, these measures produce status that is considered health-enhancing (see e.g., Marmot [7]). While closely related, the three measures are not interchangeable [8, 9].

A growing literature suggests that *subjective* SEP measures are also powerful determinants of health [10]. Rather than focusing solely on objective indicators of SEP, inequalities in subjective SEP could be as important, or even more strongly linked to health than objective SEP measures [11, 12]. This builds on the hypothesis that subjective SEP captures socioeconomic dimensions not measured by objective SEP indicators [13, 14]. For example, in The English Longitudinal Study of Ageing, it was found that subjective SEP mediated the association between objective SEP measures and mortality, as well as independently predicting mortality [10]. Additionally, none of the objective SEP indicators directly measure socially derived attributions of prestige or status [15]. This suggests that objective SEP measures should be complemented by a measure of subjective SEP.

The association between SEP and health has been observed with each of the three objective SEP indicators, which could indicate that SEP represents a broader, underlying construct related to social stratification [16]. Therefore, if these SEP variables capture different aspects of the same concept [6], a composite measure could better represent SEP when estimating social inequalities in health [17]. Additionally, a composite SEP measure may capture multiple aspects of relevance when estimating how individuals' SEP influences health inequalities, thus simplifying interpretation [18] and communication of results [19].

In the literature on social inequalities in health, composite indicators of SEP are applied in different ways. The focus here will be on individual-level composite indicators. Early examples include the Hollingshead index of social status [20], using a priori defined weights for education and occupation; the Duncan's socioeconomic index for occupational prestige; and the Nam-Powers occupational status score [19, 21]. These indicators are not as relevant today due to changes in eduation and the labour market [22]. However, the Nam-Powers score has in later years been updated and refined into the Nam-Powers-Boyd occupational score, using data from the 2010–12 American Community Surveys, in which median education and median earnings of different occupations are used as the basis for the score [23]. In the UK, occupation is widely used for socioeconomic classifications [6]. In application today is the National Statistics Socio-economic classification, which incorporates employment relations and conditions of occupations, into non-hierarchical occupational classes [24]. The latter two examples are limited to the US and UK contexts, and would need to be adjusted to fit other contexts. Other recent examples of composite SEP indicators most frequently use education, occupation and income for composite SEP indices (see e.g., [25, 26]), as well as education and income only (e.g., [27, 28]).

A common critique against composite SEP measures is that they conceal the relative influence of their components [29]. However, it can also be argued that a composite indicator of SEP can capture the synergies between its different components [17]. In this paper, we propose a composite SEP score that compiles several SEP indicators into one, that still allows for disaggregation of the score's components.

In the literature on social inequalities, the most common health indicators are mortality or disease-specific health outcomes (e.g., [30–32]), or self-rated health [33]. In this paper, we use two measures of health-related quality of life (HRQoL): the multidimensional EQ-5D-5L descriptive system, and a visual analogue scale (VAS).

The current paper is based on data from a general adult population and aims to: i) develop a composite SEP score from empirically derived weights that reflect individuals' subjective SEP; and ii) test how the composite SEP score predicts inequalities in HRQoL. We regress subjective SEP on education and income levels. The resulting weights are used to predict a SEP value for each individual based on combinations of their education and income levels. We further demonstrate how the composite SEP score predicts inequalities in HRQoL. This study contributes to the literature by proposing a simple composite SEP score based on the two most widely collected objective indicators of SEP using derived weights according to their influence on subjective SEP.

Conceptual framework

The concept of SEP is complex. It is therefore necessary to describe its components and the hypothesised relationships between them.

Education proxies an individual's cognitive resources and the ability to process health information [4]. In addition, education has been found to be strongly associated with childhood socieconomic conditions (see e.g., [34]), and can, as such, be understood as a representation of early-life circumstances. Education is often measured as the highest level of educational attainment, or as years of education.

Occupation mirrors educational achievement, yields income, and reflects individuals' social standing [35]. Occupation indicators can capture the prestige associated with specific professions; environmental exposures

on the job (e.g., pollution); or psychosocial aspects, such as job strain and satisfaction [6].

Income is hypothesised to impact health through the ways in which individuals' resources provide a healthy physical environment, healthier lifestyle and/or ease of access to health services. Additionally, income itself can entail a higher SEP [6].

These three indicators can be conceptualised as components of the latent construct of objective SEP. This is shown in our conceptual framework (Fig. 1), which demonstrates the hypothesised links between the key concepts included in this paper. Education provides skills and knowledge that qualify people for specific occupations. The higher education level that an occupation requires, the more cognitive resources and skills does the individual possess, all of which are associated with objective SEP. However, occupations with similar levels of educational attainment (e.g., a physician vs a priest) differ immensely in terms of income levels: having a high income, then, reflects that the individual has an occupation that society values more highly. Thus, education, occupation, and income represent the concept of objective SEP, displayed in Fig. 1, as encompassing these three indicators. In this framework, objective SEP predicts subjective SEP, which in turn, determines HRQoL. Additionally, age and sex are added as covariates, as they are assumed to influence both subjective SEP and HRQoL. They will also likely influence objective SEP, but this model focuses on how they relate to subjective SEP. Lastly, although not included in this paper, it is important to acknowledge the role played by the intergenerational transmission of both socioeconomic factors and health. It is widely established that parents not only transfer their genes to their offspring, but also their SEP and health (behaviours) [36–38].

In the current study, occupational category is not directly included in the composite SEP score. However, it is indirectly captured, in that occupation (to a large extent) is determined by education, *and* (to an even larger extent) a determinant of income. As opposed to education, measured in years; and income, measured in money, occupational categories can be more difficult to hierarchically order. This is because the categories include individuals with large differences in skills, prestige, power, and/or incomes, and are arguably not originally developed as a SEP measure [8]. Moreover, occupational measures vary widely in what they proxy and are likely to differ substantially between countries and different contexts [4]. In this sense, education and income are more consistently available from surveys and registers than occupation.

Methods

Data

The Tromsø Study is a prospective cohort study from a general adult population residing in the municipality of Tromsø. With approximately 77,000 inhabitants, Tromsø is the largest city in Northern Norway. The current paper is based on data from the seventh wave conducted in 2015/16. Of the 32,591 people that were invited (aged 40 years and older), $N=21,083$ (65%) completed the survey. The study design is described in detail elsewhere [39].

The study was approved by the Regional Committee for Medical Research Ethics Northern Norway (REK North; ID 2019/607). The Tromsø Study complies with the Declaration of Helsinki and all participants gave written informed consent before admission. Data access was granted by the Data and Publication Committee of the Tromsø Study. All methods were carried out in accordance with relevant guidelines and regulations.

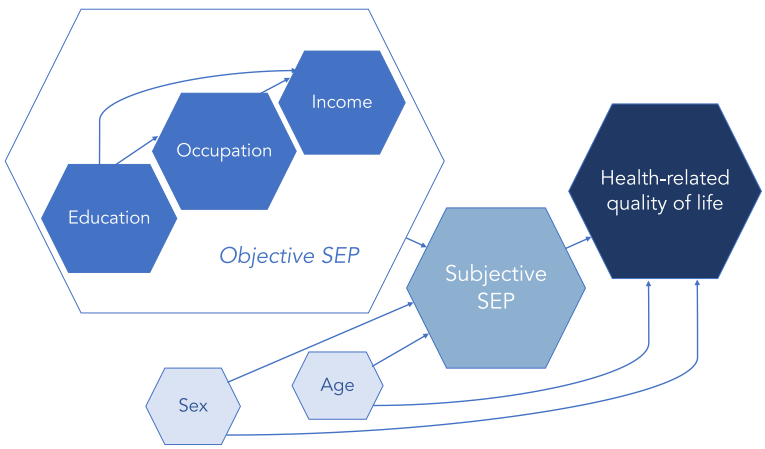

Fig. 1 Conceptual framework of the relationship between the components of SEP and HRQoL. Note: Arrows reflect hypothesised associations between key concepts. SEP: socioeconomic position

Variables

Education was recorded as the highest completed education level, categorised into four: primary education up to ten years; upper secondary and vocational school; undergraduate (less than four years of higher education); and postgraduate degree (four years or more of higher education).

Income was recorded as the combined gross income of adults in the household, in eight income brackets. These were collapsed to approximate quartiles. Income groups were (per NOK 1,000): Low: ≤ NOK 450 (20.9%); Lower middle: NOK 451–750 (29.3%); Upper middle: NOK 751–999 (24.2%); and High: NOK ≥ 1 million (25.6%).

Inspired by the seminal work of Marmot on the crucial role of social status [7], we used subjective SEP to develop the composite SEP score. Subjective SEP was obtained from the statement 'I consider my occupation to have the following social status (if you are currently out of work, think about your latest occupation)', which was rated using a five-level scale (very high; fairly high; middle; fairly low; very low). With few respondents in the lowest category (< 1%), we collapsed the bottom one into the category for 'low' status, leaving subjective SEP as a four-level ordinal variable. The subjective SEP measure is framed in terms of the perceived SEP of respondents' *occupation*, as an individual's occupation is thought to largely shape the perception of own social standing. It is a variant of the more commonly applied MacArthur scale of subjective social status [11].

HRQoL was the main outcome variable and was measured in two ways: directly on a VAS, and indirectly with the EuroQol EQ-5D. The EQ-5D is the most widely applied generic preference-based descriptive system [40, 41]. It describes health along five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression [42]. We applied the most recent version with five severity levels along each dimension (EQ-5D-5L) [43]: 'no problems', 'slight problems', 'moderate problems', 'severe problems', and 'unable'. In the absence of a Scandinavian value set for the EQ-5D, we used an amalgam tariff, the Western preference pattern (WePP), representing a hybrid of four Western countries' published value sets [44]. The VAS asks respondents to rate their health today on a scale from [0–100]. The VAS was converted into a [0–1] interval for reasonable comparison with the EQ-5D value.

Age and sex were included as covariates.

Statistical analyses

Descriptive statistics

Means, proportions, and standard deviations (SD) of the included variables were reported for the full sample and stratified by sex. We excluded respondents above the age of 80 (N = 761) due to a disproportionately low response rate and to diminish the impact of cohort effects on the education variable, leaving a sample of $N = 20{,}322$. For the analyses, respondents with missing observations for education and income were excluded, corresponding to 4.5% of the sample.

Regression-based approach to develop a composite SEP score

To develop the composite SEP score, we applied subjective SEP as the dependent variable, proxying SEP. We used adjacent-category logistic regression, which is an alternative to classical ordered logistic regression. This method compares each category (level) of the dependent variable with the next larger response category [45]. We modelled the four-level subjective SEP (*sSEP*) variable as a function of education (*Educ*), and income (*Inc*) (Eq. 1). The education and income variables were dummy-coded, with the lowest level serving as the reference level for each variable. Sex and age (in years) were included as control variables (X):

$$sSEP = f(Educ, Inc, X) \tag{1}$$

The resulting regression coefficients from Eq. 1 were used as education and income weights in the composite SEP score. Each of the education and income levels was multiplied with their corresponding regression coefficient, resulting in a composite SEP score that predicts individuals' SEP, demonstrated in Eq. 2:

$$SEP_i = \sum_{j=1}^{k} \beta_j * Educ_{ij} + \sum_{j=1}^{k} \gamma_j * Inc_{ij} \tag{2}$$

This approach was inspired by Mehta et al. [46]: instead of using the risk ratios to construct a summary score, the composite SEP score was generated based on the regression coefficients modelled in Eq. 1. The SEP summary score from Eq. 2 was rescaled into a [1–10] interval to form the composite SEP score: first, the coefficients for all combinations of education and income level j were added together. Second, each value of the composite SEP score was rounded to the nearest integer, resulting in a predicted SEP value [1–10] for each individual i based on their combinations of income and education levels. As such, we identified how different levels of education and income influence subjective SEP.

Predicting variation in HRQoL

To evaluate how the composite SEP score predicted variation in HRQoL (EQ-5D and VAS), we ran ordinary least squares (OLS) regression of HRQoL on the composite SEP score, adjusted for age and sex. Further, we calculated the age-adjusted predicted mean HRQoL values (EQ-5D and VAS) for all values of the SEP score.

As an alternative analysis of variation in HRQoL, we applied the concentration index (CI). The CI measures

the degree of socioeconomic inequality in HRQoL [47]. The CI's range is [-1,1], with the value 0 indicating perfect equality. A positive (negative) value indicates that the distribution of HRQoL is 'pro-high SEP' ('pro-low SEP') [48]. We compared CIs using the SEP score as the variable from which to rank individuals, with education and income.

Sensitivity analyses

We performed age-stratified analyses to assess whether the education and income weights derived for the composite SEP score differed across age groups. These analyses were conducted by running separate adjacent-category logistic regression analyses stratified by age groups (40–49; 50–65; and 66–79). Sex-specific analyses were also conducted, as well as analyses including only respondents who were currently in the labour force (full or part time). Lastly, we tested equivalising the household income variable with marital status.

We randomly split the sample in equal halves (referred to as Subsamples 1 and 2), before rerunning the adjacent-category logistic regression as in Eq. 1 on both samples. Next, we conducted the same procedure as in Eq. 2, using regression coefficients from Subsample 1, generating an alternative composite SEP score. With OLS regression, we tested how well the composite SEP score with weights from Subsample 1 performed in predicting HRQoL (EQ-5D and VAS) in Subsample 2. We assessed how these estimates (composite SEP score coefficients and the R^2) differed from the analyses on HRQoL run on the full sample.

All statistical analyses were performed with Stata© version 15.1 (Stata Corporation, College Station, Texas).

Results

Descriptive statistics

Table 1 reports respondent characteristics. Given that this is a community sample, respondents were healthy in general, with a mean EQ-5D value of 0.89 and a mean VAS score of 0.76. Among them, 28.6% can be classified as in 'full health', i.e., they reported 'no problems' in all five EQ-5D-5L dimensions. The proportion of the sample with tertiary level education was larger than in the

Table 1 Sample characteristics

Variables	Female		Male		Total	
	Mean/%	N	Mean/%	N	Mean/%	N
Age, mean (SD)	56.2 (10.36)	10,661	56.5 (10.44)	9,661	56.3 (10.40)	20,322
Education level						
Primary education < 10 yrs	22.6	2,375	21.4	2,033	22.0	4,408
Upper secondary/vocational	25.5	2,681	30.6	2,915	27.9	5,596
Undergraduate degree	18.0	1,890	21.4	2,040	19.6	3,930
Postgraduate degree	33.9	3,561	26.6	2,532	30.4	6,093
Income						
Low	25.2	2,546	16.3	1,542	20.9	4,088
Lower middle	30.0	3,033	28.6	2,700	29.3	5,733
Upper middle	22.4	2,265	26.0	2,462	24.2	4,727
High	22.3	2,257	29.1	2,753	25.6	5,010
Subjective SEP						
Very low/low	7.6	784	6.2	587	6.9	1,371
Middle	54.5	5,638	47.1	4,449	51.0	10,087
Fairly high	31.9	3,295	38.7	3,657	35.1	6,952
Very high	6.1	627	8.1	761	7.0	1,388
HRQoL: EQ-5D-5L						
Full health (11111), %	24.9	2,560	32.6	3,034	28.6	5,594
Mean	0.88	10,275	0.90	9,322	0.89	19,597
(SD)	(0.11)		(0.10)		(0.11)	
HRQoL: VAS score	0.76	10,472	0.77	9,500	0.76	19,972
(SD)	(0.17)		(0.15)		(0.16)	

The undergraduate and postgraduate education levels correspond to university education up to four years and university education of four years or more, respectively; mean value for EQ-5D-5L measured by WePP: Western Preference Pattern. SD: standard deviation; HRQoL: health-related quality of life; VAS: visual analogue scale, converted into a [0–1] interval

corresponding age group from the Norwegian population (50.0% compared to 33.1%, respectively) [49].

Weights for the composite SEP score

Table 2 displays the adjacent-category logistic regression output. Education was the main driver for subjective SEP, as demonstrated by the clear increase in the size of the education coefficient for each level change, particularly so for a postgraduate degree. For income, there was a non-linear increase in the size of the coefficients, with the highest income coefficient being thrice as large as the upper-middle income coefficient.

The weights derived were used to generate the composite SEP score (Eq. 2). The rescaled and rounded SEP score is reported in a '4X4 SEP table' (Table 3). This table indicates that the observed non-linearities reported in Table 2 are reinforced when combining education and income levels.

Predicting variation in HRQoL with the composite SEP score

Table 4 provides the results from the OLS regression of the composite SEP score on both HRQoL measures (EQ-5D and VAS). A one-unit increase in SEP is associated with an average increase of 0.006 in the case of EQ-5D and 0.010 for VAS. Comparing the results with OLS regression of education and income separately led to a similar model fit based on the R^2 (output not shown).

Figure 2 presents age-adjusted mean EQ-5D values and VAS scores by SEP score levels. There was a clear linear increase in the reported HRQoL scores as the SEP values increased from 1 to 10, with EQ-5D values consistently

Table 2 Adjacent-category logistic regression on subjective SEP: weights for the composite SEP score based on education and income

	Coefficient (SE)
Education level	
Primary education < 10 yrs	Ref
Upper secondary/ vocational	0.141*** (0.034)
Undergraduate degree	0.697*** (0.038)
Postgraduate degree	1.293*** (0.037)
Income	
Low income	Ref
Lower-middle income	0.193*** (0.034)
Upper-middle income	0.261*** (0.037)
High income	0.822*** (0.039)
Demographic characteristics	
Age (years)	0.020*** (0.001)
Male	0.270*** (0.023)
Constant 1	0.180** (0.083)
Constant 2	-2.543*** (0.142)
Constant 3	-4.233*** (0.194)
Observations	*18,988*
AIC	*37,550*
Pseudo R^2	*0.0886*

*** p < 0.01, ** p < 0.05, * p < 0.1. The undergraduate and postgraduate education levels correspond to university education up to four years, and university education of four years or more, respectively; SE: Standard errors in parentheses; Male: binary variable: 0 = female; 1 = male; AIC: Akaike's Information Criterion

Table 3 '4X4 SEP' table, combining education and income levels

	Income			
	Low	Lower-middle	Upper-middle	High
Education				
Primary education < 10 yrs	1	2	2	4
Upper secondary/vocational	2	2	3	5
Undergraduate degree	4	5	5	7
Postgraduate degree	7	7	8	10

Predicted socioeconomic position (SEP) score based on all combinations of education and income levels

Table 4 Ordinary least squares regression on HRQoL (EQ-5D-5L values and VAS scores) with the composite SEP score as the independent variable

	EQ-5D Coefficient (Robust SE)	VAS Coefficient (Robust SE)
Composite SEP score	0.006*** (0.000)	0.010*** (0.000)
Age (yrs)	0.001*** (0.000)	< 0.001*** (0.000)
Male	0.022*** (0.002)	0.002 (0.002)
Constant	0.820*** (0.005)	0.689*** (0.008)
Observations	*18,761*	*19,119*
R^2	*0.0369*	*0.0338*

*** p < 0.01, ** p < 0.05, * p < 0.1; HRQoL was measured by the WePP: Western Preference Pattern for EQ-5D-5L; and the VAS: visual analogue scale; Male: binary variable: 0 = female; 1 = male; robust standard errors (SE) in parentheses

higher than the VAS scores. The gradient was steeper for VAS (range: 0.72–0.82) than for EQ-5D (range: 0.87–0.92).

The concentration indices of HRQoL are reported in Additional file 1. The CIs using the SEP score were 0.020 and 0.040 for EQ-5D and VAS, respectively. The CIs using education and income were slightly larger. The positive values of the CI indicate that better HRQoL were concentrated among respondents with a higher SEP.

Sensitivity analyses

Age-group stratified analyses of the determinants of subjective SEP indicated that the importance of education increased with age, whereas income became less important with age (Additional file 2). In terms of sex differences, the second-lowest education level was not statistically different from the reference among women. The patterns are the same as in the main model, with increasing coefficient sizes for each level increase in education and income (Additional file 3). Restricting the sample to respondents who stated being actively employed led to similar results as the main model, except for a non-significant upper secondary education coefficient (Additional file 4). Analysing household income equivalised for marital status did not lead to substantially different estimates. This output was therefore not included.

Using the composite SEP score with weights generated from Subsample 1 (Additional file 5) to predict both EQ-5D and VAS on Subsample 2, the coefficients remained similar and the change in R^2 was marginal (Additional file 6).

Discussion

This paper has proposed a composite SEP score by modelling individuals' subjective SEP based on four education and four income levels. The derived weights demonstrated how education and income influenced subjective SEP. There were non-linearities in determining subjective SEP, with greater importance placed on the higher education and income levels. These non-linearities became more evident when combining the different education and income levels, indicating that higher levels of education and income reinforced each other. The score was used to estimate inequalities in HRQoL based on combinations of education and income, and for each level of the composite SEP score. We found a clear gradient in HRQoL, with a linear increase from the bottom to the top of the score.

The proposed composite SEP score was derived from a measure of *subjective* SEP. This is in line with research recognising the added value of supplementing objective measures with subjective measures [12, 13, 50]. We contribute to the literature with a composite SEP score that captured both subjective and objective aspects of SEP, in which the objective indicators (education and income) estimated the subjective component (subjective SEP). The subjective SEP measure applied here differs from the more commonly used MacArthur scale of subjective social status [11]. Whereas the MacArthur scale is framed in terms of education, occupation and income, the subjective SEP measure is closely tied to occupation. Moreover, it should not be confused with occupational

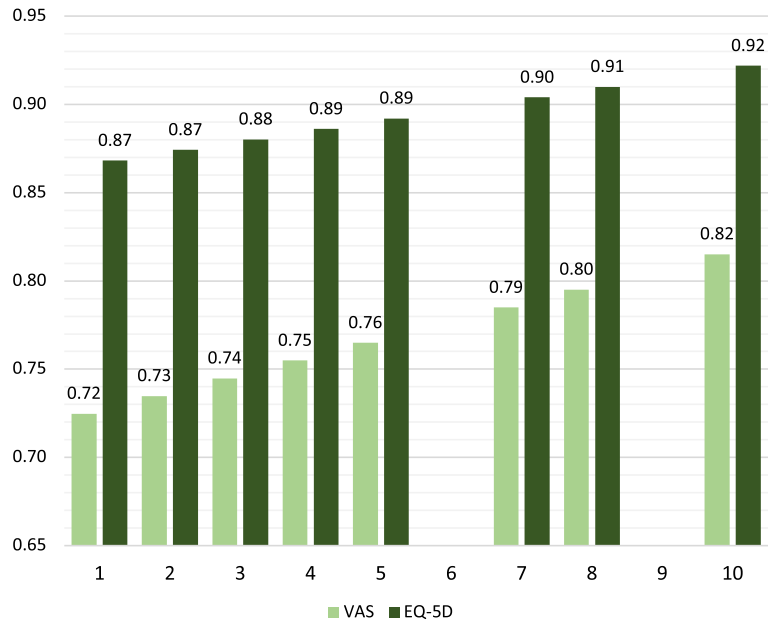

Fig. 2 Age-adjusted mean EQ-5D values and VAS scores by composite SEP score. Mean VAS scores (left bars) and EQ-5D values (right bars) for each SEP score. SEP scores 6 and 9 are empty due to no data for these SEP score values. SEP: socioeconomic position

prestige, since the measure applied in this paper captures individuals' perception of their own occupation's social status, not the society's judgement of the status of specific occupations [35].

The composite SEP score was estimated by education and income. Occupational category was not included in the estimation because we assumed that its influence on SEP was captured in its intermediate role between education (the determinant of occupation) and income (the reward of occupation). Moreover, in contrast to education (years) and income (money), the occupational categories are not as easily hierarchically ordered, in line with the arguments presented by Braveman et al. [8]. Education and income are more often consistently measured and available across different surveys and registers [27]. Besides, social standing derived from occupation is arguably more context dependent: a fisherman's standing is likely judged higher in his local community than in the big city. We therefore followed Freeman et al. in omitting occupation [27].

Furthermore, the role of parental and early-life SEP when determining adult SEP must be acknowledged, the importance of which is consistently found to be substantial in the literature: children born to parents with higher SEP are more likely to prosper both in terms of socioeconomic achievements and in terms of health (e.g., [34, 51]). These factors are essential in the understanding of SEP.

The observed non-linear relationship of education and income in determining subjective SEP was evident from Table 3, with large marginal increases in subjective SEP from the highest education level, regardless of income. These non-linearities are likely to have different explanations. For example, Norway has a relatively egalitarian income distribution and a generous welfare state, which is likely to contribute to income being of less importance for most people. For the richest, however, income could matter more for SEP, potentially because social success can be signalled through various types of conspicuous consumption [52], such as living in a posh neighbourhood.

Age-stratified analyses added additional insights on cohort effects. Education appeared to matter more for the older age groups, whereas the size of the income coefficients decreased with age (Additional file 1). This could imply that education was a relatively stronger determinant of subjective SEP for those who did have higher education in the oldest age group (66–79). Indeed, the share of people opting for higher education has dramatically increased over the past generations, suggesting that higher education was more important for SEP when it was more of a privilege for the few. Cohort effects are also relevant in the case of sex differences (Additional file 3), in that women constitute a larger share of those taking higher education. The non-significant upper secondary/vocational coefficient in women could reflect that taking higher education is more important for women's SEP than for men's.

The relative importance of education and income in predicting SEP will likely vary between countries [53, 54]. If a similar analysis had been performed in a country with larger income inequalities than Norway, there would likely be starker differences between all the income categories, not only the top one as in this sample. Therefore, it is important to consider international differences in the relative importance of socioeconomic factors as determinants of SEP.

Our results indicated that the composite SEP score predicted considerable variation in HRQoL. Although there was no difference in the predictive power of the composite SEP score model compared to analysing education and income separately, it is arguably a more convenient way to calculate the combined impact of education and income on health inequalities, rather than conducting separate analyses [17, 55]. Moreover, the composite SEP score allowed us to demonstrate a linear increase in the age-adjusted HRQoL value by SEP score level for both the EQ-5D and the VAS (Fig. 2). This indicates a clear social gradient in both HRQoL measures, a message that would be hard to communicate with separate indicators.

The use of an alternative measure of inequality, the concentration index, suggested that inequalities in HRQoL are concentrated among higher-SEP groups, although the degree of inequality is relatively low (Additional file 1). The CIs of education and income were slightly larger than those of the composite SEP score, which could suggest that the combination of education and income somewhat compensates for differential variation in these two SEP variables. The order of magnitude of these results is comparable to other studies investigating inequalities in HRQoL [48, 56].

For the split-sample analyses, the estimates from the OLS analysis with the alternative composite SEP score (Additional file 6) did not differ greatly from the results in Table 4. This suggests that our estimates were internally valid.

Strengths and limitations

The key contribution of the current paper is that we provide a new application of a regression-based method for developing a composite SEP score with empirically derived education and income weights along a [1-10] SEP scale. Since education is grouped into the standard four levels, and income is approximately grouped into quartiles, our proposed approach can be replicated in any cohort study that collects these data, on any health outcome. Second, we provide new insights into the relative importance of different education and income levels as sources of SEP. Third, we have shown how SEP in the form of a composite score can be applied in analyses of health inequalities.

Some limitations should be acknowledged. First, the sample consists of respondents aged 40–79, leaving

out the younger segment of the adult population. Second, since the subjective SEP measure targets people in the labour force, there is a risk that respondents who did not work at the time of the survey did not answer the question 'correctly', although the question specified that those who were not currently working should think about their latest occupation, assuming that an individual's *previous* occupation is important for their current SEP. Sensitivity analyses indicated that including only currently employed respondents did not dramatically differ from the main results. Third, although a missing rate of observations of 4.5% is relatively small, there could still be systematic differences between the included and excluded shares of the sample. Missing value analysis indicated that those not reporting education or income were older and had a larger proportion of women compared to the full sample. We therefore cannot rule out that our results could underestimate inequalities, since older respondents would be more likely to report a lower HRQoL.

Conclusions

Our results suggest that a composite SEP score should be considered when studying social inequalities in health. We have proposed a model for a composite SEP score that predicts individuals' SEP based on empirically weighted combinations of education and income levels, which identified a clear social gradient in HRQoL. This approach could be used when data on education and income are collected, either in cohort studies or through registers, potentially predicting the SEP of the entire population. The weights derived in this paper are relevant in a Norwegian context. Research from other countries is needed to compare the relative importance of education and income as determinants of SEP across countries, and to investigate how a composite SEP score would predict health inequalities in other institutional contexts.

Abbreviations

CI: Concentration Index; EQ-5D: EuroQol Five-dimensional Measure of Health-related Quality of Life; HRQoL: Health-Related Quality of Life; OLS: Ordinary Least Squares; SD: Standard Deviation; SE: Standard Error; SEP: Socioeconomic Position; VAS: Visual Analogue Scale; WePP: Western Preference Pattern.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-022-13366-8.

Additional file 1. Concentration index of EQ-5D and VAS

Additional file 2. Adjacent-category logisticregression on subjective social status: weights for composite SEP score,stratified by age groups.

Additional file 3. Adjacent-category logistic regression onsubjective SEP: stratified by sex.

Additional file 4. Adjacent-category logistic regression onsubjective SEP, including only currently employed respondents (full or parttime).

Additional file 5. Adjacent-category logistic regression onsubjective social status: weights for composite SEP score with sample randomlysplit in two.

Additional file 6. Ordinary least squares regression analysis to test internalvalidity.

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Authors' contributions

All authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: MHL, GC, JAO, BA. Material preparation, analysis and interpretation of data: MHL. Drafting of the manuscript: MHL. Critical revision of the manuscript for important intellectual content: MHL, GC, JAO, BA. All authors read and approved the final version to be published.

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Availability of data and materials

The data that support the findings of this study are available from The Tromsø Study but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. In order to get access to the data on which the present study is based, permission from the Tromsø Study is required. The Data and Publication Committee of the Tromsø Study evaluates all applications for access to data, and upon approval of application, an agreement is made between The Tromsø Study and the project manager of the project in question. Questions regarding access to data may be directed towards tromsous@ism.uit.no.

Declarations

Ethics approval and consent to participate

This study was approved by the Regional Committee for Medical Research Ethics Northern Norway (REK North; ID 2019/607). The Tromsø Study complies with the Declaration of Helsinki and all participants gave written informed consent before admission.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Publisher's Note

Additional file 1: Concentration index of EQ-5D and VAS

	SEP score CI (SE)	**Education CI** (SE)	**Income CI** (SE)
EQ-5D	0.020 (0.001)	0.022 (0.000)	0.023 (0.000)
VAS	0.040 (0.001)	0.047 (0.001)	0.043 (0.001)

Note: SEP: socioeconomic position; *CI*: concentration index; HRQoL was measured by the *WePP*: Western Preference Pattern for EQ-5D-5L; and *VAS*: visual analogue scale; standard errors (SE) in parentheses.

Additional file 2: Adjacent-category logistic regression on subjective social status: weights for composite SEP score, stratified by age groups.

	Age groups		
	40-49	**50-65**	**66+**
	Coefficients (SE)	**Coefficients (SE)**	**Coefficients (SE)**
Education level			
Primary/lower secondary school	Ref.	Ref.	Ref.
Upper secondary/ vocational school	0.051 (0.075)	0.085* (0.050)	0.319*** (0.068)
Undergraduate degree	0.606*** (0.079)	0.630*** (0.054)	0.860*** (0.079)
Post-graduate degree	1.128*** (0.077)	1.271*** (0.054)	1.428*** (0.081)
Income level			
Low income	Ref.	Ref.	Ref.
Lower-middle income	0.421*** (0.072)	0.140*** (0.053)	0.087 (0.056)
Upper-middle income	0.388*** (0.071)	0.231*** (0.054)	0.306*** (0.083)
High income	1.058*** (0.073)	0.718*** (0.056)	0.733*** (0.106)
Demographic characteristic			
Male	0.232*** (0.039)	0.247*** (0.034)	0.404*** (0.052)
Constant 1	0.841*** (0.087)	1.441*** (0.062)	1.820*** (0.080)
Constant 2	-1.621*** (0.139)	-1.348*** (0.085)	-1.247*** (0.077)
Constant 3	-3.328*** (0.198)	-3.009*** (0.128)	-2.980*** (0.142)
Observations	*6,228*	*8,800*	*3,960*
AIC	*12695*	*17300*	*7516*
Pseudo R^2	*0.0905*	*0.0884*	*0.0901*

Note: *** p<0.01, ** p<0.05, * p<0.1; the undergraduate and post-graduate education levels correspond to university education up to four years, and university education of four years or more, respectively; *Male*, binary variable: 0=female; 1=male; *SEP*: socioeconomic position; *AIC,* Akaike's Information Criterion; *SE,* standard errors in parentheses.

Additional file 3: Adjacent-category logistic regression on subjective SEP: stratified by sex

	Women	**Men**
	Coefficient (SE)	**Coefficient (SE)**
Education level		
Primary education <10 yrs	Ref.	Ref.
Upper secondary/ vocational school	0.037 (0.050)	0.220*** (0.048)
Undergraduate degree	0.657*** (0.055)	0.722*** (0.052)
Post-graduate degree	1.255*** (0.053)	1.326*** (0.054)
Household income level		
Low income	Ref.	Ref.
Lower-middle income	0.164*** (0.045)	0.243*** (0.052)
Upper-middle income	0.197*** (0.050)	0.351*** (0.055)
High income	0.669*** (0.052)	0.989*** (0.058)
Demographic characteristics		
Age (yrs)	0.017*** (0.002)	0.023*** (0.002)
Constant 1	0.546*** (0.120)	0.056 (0.118)
Constant 2	-2.300*** (0.204)	-2.526*** (0.200)
Constant 3	-3.824*** (0.277)	-4.380*** (0.276)
Observations	*9,792*	*9,196*
AIC	*19182*	*18332*
Pseudo R^2	*0.0802*	*0.0936*

Note: *** p<0.01, ** p<0.05, * p<0.1; the undergraduate and post-graduate education levels correspond to university education up to four years, and university education of four years or more, respectively; *SEP*: socioeconomic position; *AIC,* Akaike's Information Criterion; *SE,* standard errors in parentheses.

Additional file 4: Adjacent-category logistic regression on subjective SEP, including only currently employed respondents (full or part time)

	Coefficient (SE)
Educational level	
Primary education <10 yrs	Ref.
Upper secondary/ vocational school	0.017 (0.046)
Undergraduate degree	0.604*** (0.049)
Post-graduate degree	1.220*** (0.048)
Income	
Low income	Ref.
Lower-middle income	0.261*** (0.052)
Upper-middle income	0.283*** (0.052)
High income	0.892*** (0.053)
Demographic characteristics	
Age (yrs)	0.017*** (0.002)
Male	0.252*** (0.027)
Constant 1	0.427*** (0.113)
Constant 2	-2.317*** (0.191)
Constant 3	-4.063*** (0.257)
Observations	*13,371*
AIC	*26425*
Pseudo R^2	*0.0931*

Note: *** p<0.01, ** p<0.05, * p<0.1; the undergraduate and post-graduate education levels correspond to university education up to four years, and university education of four years or more, respectively; *Male*, binary variable: 0=female; 1=male; *SEP*: socioeconomic position; *AIC,* Akaike's Information Criterion; *SE,* standard errors in parentheses.

Additional file 5: Adjacent-category logistic regression on subjective social status: weights for composite SEP score with sample randomly split in two

	Subsample 1	**Subsample 2**	***Original sample (from Table 2)***
	Coefficient (SE)	**Coefficient (SE)**	***Coefficient (SE)***
Educational level			
Primary/lower secondary school	Ref.	Ref.	*Ref.*
Upper secondary/ vocational school	0.110** (0.048)	0.173*** (0.049)	*0.141*** (0.034)*
Undergraduate degree	0.647*** (0.053)	0.748*** (0.054)	*0.697*** (0.038)*
Post-graduate degree	1.252*** (0.052)	1.336*** (0.053)	*1.293*** (0.037)*
Income			
Low income	Ref.	Ref.	*Ref.*
Lower-middle income	0.218*** (0.048)	0.166*** (0.049)	*0.193*** (0.034)*
Upper-middle income	0.307*** (0.051)	0.213*** (0.052)	*0.261*** (0.037)*
High income	0.862*** (0.054)	0.779*** (0.055)	*0.822*** (0.039)*
Demographic characteristics			
Age (yrs)	0.020*** (0.002)	0.021*** (0.002)	*0.020*** (0.001)*
Male	0.270*** (0.032)	0.272*** (0.032)	*0.270*** (0.023)*
Constant 1	0.177 (0.117)	0.183 (0.119)	*0.180** (0.083)*
Constant 2	-2.498*** (0.198)	-2.588*** (0.203)	*-2.543*** (0.142)*
Constant 3	-4.202*** (0.272)	-4.266*** (0.278)	*-4.233*** (0.194)*
Observations	*9,504*	*9,843*	*18,988*
AIC	*18,892*	*18,676*	*37,550*
Pseudo R^2	*0.0882*	*0.0892*	*0.0886*

Note: *** p<0.01, ** p<0.05, * p<0.1; the undergraduate and post-graduate education levels correspond to university education up to four years, and university education of four years or more, respectively; *Male*: binary variable: 0=female; 1=male; *SEP*: socioeconomic position; *AIC*: Akaike's Information Criterion; *SE*: standard errors in parentheses. Estimates from Table 2 in the right column.

Additional file 6: Ordinary least squares regression analysis to test internal validity

	EQ-5D-5L		**VAS**	
	Subsample 2	***Full sample (from Table 4)***	**Subsample 2**	***Full sample (from Table 4)***
	Coefficients (Robust SE)	***Coefficients (Robust SE)***	**Coefficients (Robust SE)**	***Coefficients (Robust SE)***
Composite SEP score	0.006*** (0.000)	*0.006*** (0.000)*	0.010*** (0.001)	*0.010*** (0.000)*
Age (yrs)	0.001*** (0.000)	*0.001*** (0.000)*	0.001 (0.000)	*<0.001*** (0.000)*
Male	0.023*** (0.002)	*0.022*** (0.002)*	0.003 (0.003)	*0.002 (0.002)*
Constant	0.819*** (0.008)	*0.820*** (0.005)*	0.684*** (0.011)	*0.689*** (0.008)*
Observations	*9,392*	*18,761*	*9,821*	*19,119*
R^2	*0.0385*	*0.0369*	*0.0328*	*0.0338*

Note: *** p<0.01, ** p<0.05, * p<0.1; *WePP*, Western Preference Pattern for EQ-5D-5L; *VAS*, visual analogue scale; *Male*, binary variable: 0=female; 1=male; *SEP*: socioeconomic position; robust standard errors (*SE*) in parentheses. Split-sample test using weights generated from Subsample 1, on Subsample 2, with EQ-5D and VAS as dependent variables, in the left and right panels, respectively.

Paper II

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Explaining subjective social status in two countries: The relative importance of education, occupation, income and childhood circumstances.

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Explaining subjective social status in two countries: The relative importance of education, occupation, income and childhood circumstances

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ABSTRACT

In the literature on social inequalities in health, subjective socioeconomic position (SEP) is increasingly applied as a determinant of health, motivated by the hypothesis that having a high subjective SEP is health-enhancing. However, the relative importance of determinants of subjective SEP is not well understood. Objective SEP indicators, such as education, occupation and income, are assumed to determine individuals' position in the status hierarchy. Furthermore, an extensive literature has shown that past childhood SEP affects adult health. Does it also affect subjective SEP? In this paper, we estimate the relative importance of i) the common objective SEP indicators (education, occupation and income) in explaining subjective SEP, and ii) childhood SEP (childhood financial circumstances and parents' education) in determining subjective SEP, after controlling for objective SEP. Given that the relative importance of these factors is expected to differ across institutional settings, we compare data from two countries: Australia and Norway. We use data from an online survey based on adult samples, with N ≈ 1400 from each country. Ordinary least squares regression is conducted to assess how objective and childhood SEP indicators predict subjective SEP. We use Shapley value decomposition to estimate the relative importance of these factors in explaining subjective SEP. Income was the strongest predictor of subjective SEP in Australia; in Norway, it was occupation. Of the childhood SEP variables, childhood financial circumstances were significantly associated with subjective SEP, even after controlling for objective SEP. This association was the strongest in the Norwegian sample. Only the mother's education had a significant impact on subjective SEP. Our findings highlight the need to understand the specific mechanisms between objective and subjective SEP as determinants of inequalities in health, and to assess the role of institutional factors in influencing these complex relationships.

1. Introduction

In the literature on social inequalities in health, different indicators for socioeconomic position (SEP), most commonly education, occupation and income, are applied (Galobardes et al., 2007). These objective SEP indicators are used to place individuals in the status hierarchy when analysing social inequalities in health. Additionally, an increasingly applied indicator is subjective SEP, also referred to as subjective social status, that reflects how the objective SEP influences individuals' perceived placement in the social hierarchy (Demakakos et al., 2018; Jackman & Jackman, 1973; Nobles et al., 2013). However, little is known about the relative importance individuals place on these objective SEP indicators when judging their position in society.

A high subjective SEP is hypothesised to be health-enhancing (Marmot, 2004); a range of studies has documented that subjective SEP predicts various health outcomes above and beyond objective SEP measures. The most studied health outcome in this regard is self-rated health (see e.g., Demakakos et al., 2008; Präg, 2020), but subjective SEP has also been found to predict outcomes such as mortality (Demakakos et al., 2018), depression (Singh-Manoux et al., 2003), cortisol levels (Wright & Steptoe, 2005), obesity (Goodman et al., 2003), and vulnerability to the common cold (Cohen et al., 2008).

The hypothesised association between subjective SEP and health inequalities is rooted in psychosocial explanatory pathways (Schnittker

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& McLeod, 2005). People internalise perceptions of their position in socioeconomic hierarchies through social comparison, which may influence health via neuroendocrine mechanisms related to stress (McEwen & Gianaros, 2010; Nobles et al., 2013). From this perspective, the feeling of inferiority is considered to be a risk factor in itself (Marmot, 2004; Theodossiou & Zangelidis, 2009; Wilkinson, 1999). Subjective SEP is, therefore, both strongly determined by objective SEP, but is also considered a distinct construct, as subjective SEP picks up other aspects than objective SEP in capturing how socioeconomic factors influence health (Demakakos et al., 2008).

Further, extensive literature has established that childhood SEP affects adult health (see e.g., Case et al., 2005; Cohen et al., 2010; Nettle & Bateson, 2017; Smith et al., 1997); however, the many pathways through which this occurs are challenging to trace. The association between childhood and subjective SEP could potentially explain the pathway from childhood SEP to adult health via the status generated from growing up with a 'silver spoon'. However, the influence of childhood SEP on subjective SEP in adulthood has been sparsely studied (Ferreira et al., 2018; Kim & Radoias, 2019), especially in Western contexts.

The association between childhood and subjective SEP would indicate that not only objective SEP, but also childhood SEP determines subjective SEP: the better the conditions during childhood, the higher the subjective SEP. Nevertheless, the *relative importance* of objective SEP on the one hand and childhood SEP on the other, in determining subjective SEP, remains unknown. Identifying their relative importance is important for developing appropriate policy responses that mitigate the impact of exposure to damaging socioeconomic factors.

The relative importance of determinants of subjective SEP is likely to vary across countries with different macro-level contexts (e.g., economic growth, unemployment rate) and institutional settings (such as social policies), since these factors are likely to shape the determinants of individuals' subjective SEP. This paper compares Australia and Norway, which have similar life expectancies, and they both rank high on the Human Development Index (Australia 6th, and Norway 1st; UNDP, 2020). In terms of income inequality, measured using the Gini index, Australia (0.33) is more unequal than Norway (0.26) (OECD, 2018a). While both countries have a publicly funded national health service, it is more common in Australia to have voluntary private health insurance (Australian Institute of Health and Welfare, 2020). The share of the population with higher education is similar in the two countries, although it is more common in Norway to pursue postgraduate degrees (10.3% in Norway vs 5.4% in Australia; Australian Bureau of Statistics, 2017; Statistics Norway, 2019).

In this paper, we have quantified respondents' implicit weighting of education, occupation and income in explaining their own subjective SEP, as the relative importance of these factors is not well understood in the assessment of subjective SEP (Navarro-Carrillo et al., 2020). We have further provided new insights into the importance of childhood SEP, measured using childhood financial circumstances and parents' education level, in determining subjective SEP, to investigate whether there are determinants of adult subjective SEP that can be traced back to early-life conditions, independently of objective SEP.

The aim of this study was to estimate the relative importance of a) objective SEP indicators (education, occupation and income), and b) childhood SEP, independent of objective SEP, in determining subjective SEP in adulthood. Since the relative importance of these components is expected to differ across institutional settings, we have compared data from two countries. The paper is structured as follows: Section 2 describes the data, variables and methods and Section 3 presents the results, followed by a discussion in Section 4 and conclusions in Section 5.

2. Material and methods

2.1. Data

An anonymous survey was developed on an online survey platform, Qualtrics (www.qualtrics.com). Request responses were set up to increase the question response rate such that respondents were reminded to complete the missing question before moving to the next page, to reduce the number of missing values. The respondents were recruited by Cint (www.cint.com), a global panel company, among members of its panel in December 2018–February 2019. For each country, a targeting sample size of 1400 was used and demographic quotas (with regard to the age and sex distribution) were applied. Initially, a total of 1920 respondents in Australia and 2418 in Norway consented and clicked the survey link. Next, respondents were excluded if they a) did not submit the survey, or the quota was full (N = 249 in Australia; N = 665 in Norway); or b) failed quality thresholds, e.g., spent less than 5 min to complete the survey (N = 248 in Australia; N = 353 in Norway). After the exclusion, the Australian and Norwegian sample sizes were left at N = 1423 and N = 1,400, respectively. Upon completion of the survey, panel members received a small amount of reimbursement for their time and effort to complete the survey. As an example, Cint has successfully facilitated a large multi-instrument comparison study on quality of life and subjective wellbeing across six countries (Richardson et al., 2016).

Post-stratification weights were created after data collection to align the respondent data with population statistics of each country according to age group and sex. The study was approved by the Monash University Human Research Ethics Committee (project ID: 17490).

2.2. Variables

The outcome variable, subjective SEP, was measured with the MacArthur scale of subjective social status (Adler et al., 2000), developed to examine how subjective status determines health (Singh-Manoux et al., 2003). The MacArthur scale was originally developed for the US (Adler et al., 2000), but has since been applied in various contexts and populations, making it a frequently applied measure of subjective SEP. The respondents were instructed to place themselves on a ladder with rungs 1–10: 'Think of the ladder as representing where people stand in society. At the top of the ladder are the people who are best off – those who have the most money, education and the best jobs. At the bottom are the people who are worst off – those who have the least money, least education and the worst jobs or no job. The higher up you are on this ladder, the closer you are to people at the very top, and the lower you are, the closer you are to the bottom'. The variable was analysed as a continuous measure ranging from 1 to 10, with higher values denoting higher subjective SEP.

Education was recorded based on the highest completed of four education levels: primary education up to ten years; upper secondary and vocational school; undergraduate (less than four years of higher education); and postgraduate degree (higher education of four years or more). For the analyses, we used the upper secondary level as the reference due to few respondents in the primary education category in the Norwegian sample.

Income was recorded as the combined gross income of adults in the household, with eight income brackets in the Norwegian sample and ten in the Australian. For the analysis, income was recorded into five categories to approximate similar distributions across income groups for the two samples.

Occupation was grouped into five categories: *not in labour force*; *machinery operators, drivers and labourers*; *sales, clerical and service workers*; *technicians and trade workers*; *managers and professionals*. For the analyses, we recoded the occupation variable into three: the categories *not in labour force* and *managers and professionals* were retained, while the other three were merged into the category *other professions*. The category *not in labour force* includes students, unemployed people and

people on disability benefits. Retired people were asked to tick the category that best described their latest occupation.

Childhood SEP was measured by factoring in childhood financial circumstances (CFC) and parental education. The CFC variable was recorded as a response to the question: 'What was your family's financial situation during your childhood?', with five possible responses: *very good*; *good*, *neither good nor bad*; *difficult*; *very difficult*. As only a few respondents selected *very difficult*, they were included into the category *difficult*. Similar indicators have been used to proxy childhood SEP in a range of epidemiological studies (see e.g., Listl et al., 2018; Straughen et al., 2013). Parents' education was recorded based on the mother's and father's highest completed of four education levels, with the same categorisation as for respondents' own education level. We analysed it by collapsing the higher (post-secondary) education levels into a *tertiary education* category and the primary and upper secondary levels into a *lower than tertiary* category. We dichotomised them due to substantial differences in the distribution of respondents between the Australian and Norwegian samples (e.g., a substantially lower share of respondents with postgraduate degrees among Australian parents than Norwegian ones). Childhood SEP was hypothesised to proxy respondents' degree of social privilege in early life.

We included age as a continuous variable. We also checked for non-linear age terms. Sex was included to investigate sex-specific differences in explaining subjective SEP.

2.3. Statistical analysis

2.3.1. Descriptive statistics

Descriptive statistics included means, proportions, and standard deviations reported by country and sex. Missing observations for subjective SEP were excluded from the analyses (N = 0 from the Australian sample; N = 6 from the Norwegian sample). In addition, N = 1 observation was deleted from each of the samples due to the reporting of unlikely high age. This left the Australian sample with N = 1422 respondents, and the Norwegian sample with N = 1393 respondents. The mean subjective SEP scores were presented by education level, income level, occupation category, CFC category and parents' education level. The difference in subjective SEP scores between Australia and Norway was tested with independent sample t-tests, using 5% as the significance level. The distributions of subjective SEP were displayed using histograms.

2.3.2. Determinants of subjective SEP

Ordinary least squares regression analysis was conducted to assess how the three objective SEP indicators (education, occupation and income) and childhood SEP (CFC and parents' education) predicted subjective SEP. All analyses were adjusted for age groups and sex. Tests of normally distributed residuals were conducted. Except for age, all other predictors were included as dummies.

We set up three regression models. Model A regressed education and income on subjective SEP, while Model B further included occupation. Model C further included childhood SEP (CFC and parents' education), referred to as the full model. Wald tests were conducted to assess whether the model coefficients in the two samples were significantly different.

Education and income were analysed separately from occupation because these variables are arguably easier to interpret. As opposed to education (measured in years) and income (measured in money), not all occupation categories can be as easily ordered. Especially in the case of Norway, the various occupational categories are not as clearly linked to a hierarchical understanding of social class as, for example, in the UK. Moreover, the status associated with different occupations are likely to depend on age, since the labour market has radically changed over the past generation. Occupation is also presumably more sensitive to contextual differences. In a comparative setting, we deemed education and income more consistent variables.

We analysed the adult current SEP predictors in the first step because the MacArthur question is framed in terms of the three objective SEP indicators (education, occupation and income), which is in line with other literature studying the relationship between objective and subjective SEP (Andersson, 2018). We then added childhood SEP because we wanted to examine its added importance in explaining subjective SEP, *after* controlling for the three common SEP predictors.

We used Shapley value decomposition to determine the predictor that was the relatively most important for subjective SEP. This is a variance decomposition technique that measures the marginal contribution to the model's explained variance, R^2, by adding any given predictor variable to the model, weighted by the number of permutations represented by a sub-model that does not contain this predictor (Shorrocks, 2013). The Shapley value therefore reports the value of adding any given predictor to the model as a proportion of R^2 (Huettner & Sunder, 2012); the larger the value, the greater that variable's relative importance in explaining subjective SEP.

We ran analyses of sex and age interactions with the subjective SEP determinants, as well as sex-stratified analyses. We also tested for interactions between each of the SEP variables. Lastly, we checked whether having a higher education level than any of their parents mattered for their reporting of subjective SEP by adding a dummy for 'educational mobility' to Model C.

All statistical analyses were performed with Stata© version 15.1 (Stata Corporation, College Station, Texas). All analyses were conducted using sample weights.

3. Results

3.1. Descriptive statistics

The sample characteristics are reported in Table 1, with means and standard deviations for continuous variables, and categorical variables as proportions. The appendix Table A.1 provides descriptive statistics of the variables reported in their originally recorded categories.

Table 2 displays the mean values of subjective SEP scores for each SEP variable in Australia and Norway, together with the *p* value for the *t*-test of the difference between the two samples' subjective SEP scores. There was a significant difference between the average subjective SEP score in Australia and Norway, as were the scores for sex. The subjective SEP mean scores were significantly different for nearly all the SEP indicator levels, except for education. For all significant differences, the Norwegian mean SEP scores were higher than the Australian ones.

The distribution of respondents across the subjective SEP ladder in Australia and in Norway is depicted in Fig. 1a and b respectively. The distribution of subjective SEP scores approximates the normal distribution.

3.2. Relative importance of objective indicators in predicting subjective SEP

Table 3 depicts the three regression models. First, education and income, adjusting for age and sex, were regressed on subjective SEP (Table 3, Model A). There was a nearly linear relationship between each increase in income level and subjective SEP, compared with the lowest income category. The association with subjective SEP indicated linearity also for education.

In Model B of Table 3, we added occupation, with *other professions* as the reference category. Most of the associations were attenuated compared to Model A. In the Australian sample, the category *not in labour force* was not significant at the 5% level. In the Norwegian sample, there was a strong negative association between being outside of the labour force and subjective SEP, and a strong positive association with subjective SEP for managers and professionals.

Including childhood SEP (Model C) slightly decreased the education coefficients in both samples, whereas income coefficients in the

Table 1
Sample characteristics.

Variables	Australia						Norway					
	Female		Male		Total		Female		Male		Total	
	Mean/%	N	Mean/%	N	Mean/%	N	Mean/%	N	Mean/%	N	Mean/%	N
Age (yrs), mean (SD)	45.4 (15.9)	731	47.0 (17.5)	691	46.2 (16.7)	1422	42.1 (15.2)	566	45.1 (17.9)	833	43.9 (16.9)	1399
Subjective SEP (SD)	5.6 (1.9)	731	5.9 (2.1)	691	5.8 (2.0)	1422	6.0 (2.1)	566	6.4 (2.0)	827	6.2 (2.1)	1393
Education level												
Primary education <10 yrs	27.5	201	24.5	169	26.0	370	8.5	48	5.5	46	6.7	94
Upper secondary	35.2	257	32.7	226	34.0	483	32.9	186	30.7	256	31.6	442
Undergraduate	22.6	165	25.0	173	23.8	338	28.1	159	29.4	245	28.9	404
Postgraduate	14.8	108	17.8	123	16.2	231	30.6	173	34.3	286	32.8	459
Occupational category												
Not in labour force	39.1	286	20.7	143	30.2	429	26.2	148	15.6	130	19.9	278
Other professions	34.0	248	41.4	286	37.6	534	49.7	281	52.8	440	51.5	721
Managers & professionals	27.0	197	37.9	262	32.3	459	24.2	137	31.6	263	28.6	400
Household income in five groups												
Low	24.5	179	20.7	143	22.6	322	26.2	148	15.3	127	19.7	275
Lower middle	26.1	191	23.4	162	24.8	353	34.3	194	29.7	247	31.5	441
Middle	21.3	156	20.3	140	20.8	296	11.7	66	13.2	110	12.6	176
Upper middle	19.0	139	24.6	170	21.7	309	18.7	106	24.6	205	22.2	311
High	9.0	66	11.0	76	10.0	142	9.2	52	17.3	144	14.0	196
Childhood financial circumstances												
Difficult	30.1	220	22.4	155	26.4	375	21.4	121	16.8	140	18.7	261
Neither good nor bad	30.9	226	30.7	212	30.8	438	34.8	197	32.4	270	33.4	467
Good	27.4	200	32.1	222	29.7	422	27.4	155	32.5	271	30.5	426
Very good	11.6	85	14.8	102	13.2	187	16.4	93	18.3	152	17.5	245
Mother's education												
≤ Upper secondary	82.5	603	75.8	524	79.3	1127	62.9	356	60.5	504	61.5	860
Tertiary education	17.5s	128	24.2	167	20.8	295	37.1	210	39.5	329	38.5	539
Father's education												
≤ Upper secondary	78.8	576	69.5	480	74.3	1056	59.4	336	57.3	477	58.1	813
Tertiary education	21.2	155	30.5	211	25.7	366	40.6	230	42.7	356	41.9	586

Note: The undergraduate and postgraduate education levels correspond to university education up to four years, and university education of four years or more, respectively. Standard deviations (SD) in parentheses for continuous variables. The household income groups correspond to the following income brackets in Australia (in AUD): Low: <35,000; Lower middle: 35,001–65,000; Middle: 65,001–100,000; Upper middle: 100,001–160,000; High: >160,001; in Norway (per 1000 NOK): Low: <349; Lower middle: 350–699; Middle: 700–849; Upper middle: 850–1199; High: >1200.

Norwegian sample increased. CFC significantly contributed to the likelihood of reporting a higher subjective SEP in both samples compared to the reference (*neither good nor bad*). In the Norwegian sample, there was no difference in the reporting of subjective SEP for those who reported *difficult* CFC. Respondents who stated *very good* CFC had a subjective SEP of more than one rung higher than the reference. In the Australian sample, the associations of CFC were not as strong, but still made an important contribution in explaining respondents' subjective SEP. CFC contributed more to R^2 in the Norwegian sample than in the Australian. In the analyses of parents' education, it was only the mother's higher education level that was significant; respondents whose mothers had university education reported 0.34 and 0.30 higher subjective SEP in Australia and Norway, respectively. Father's education was not independently associated with subjective SEP. The reporting of subjective SEP increased with age in all models (Table 3), except for a slight decrease in early adulthood in the Australian sample when adding a quadratic age term (output not reported).

Shapley value decomposition run on the full model (Table 3, Model C) indicated that income was the most important determinant in the Australian sample, and occupation the most important in the Norwegian. The relative importance of each predictor of subjective SEP is illustrated in Fig. 2, in which each predictor's importance is depicted as a share of the model's R^2. In this figure, a 100% corresponds to the percentage of total variance explained by the predictors in each country.

Separate analyses conducted with only childhood SEP as predictors of subjective SEP indicated that CFC was independently associated with subjective SEP, as the coefficients were similar to those reported in Model C (output not shown).

Wald tests of the difference between coefficients in the two samples in the full model (Model C) indicated that it was only the coefficients of category *not in labour force* that was significantly different between Australia and Norway (output not shown).

Testing age and sex interactions in Model C identified several significant interaction terms. In the Norwegian sample, there were sex differences across all income levels, where men had an advantage in terms of income-related subjective SEP. The postgraduate education and *very good* CFC coefficients were also significant, favouring women. In the Australian sample, the upper-middle income category interacted with sex. There were significant, positive age interactions for all income levels, and negative age interactions for the two upper education levels and *good* CFC (Appendix Table A.2). Analyses stratified by sex indicated differences in especially the income levels (Appendix Table A.3), in line with the sex interactions from Table A.2. The 'educational mobility' dummy added to Model C was not significant (output not reported).

4. Discussion

Social inequalities in health are commonly measured using objective SEP indicators, such as individuals' different levels of education, occupation and income. It is claimed that objective indicators 'produce' social status, and that people's perceived social status is health-enhancing (Marmot, 2004). However, little is known about the relative importance of these indicators in the subjective assessment of individuals' placement in the social hierarchy (Navarro-Carrillo et al., 2020). Furthermore, the literature has confirmed a lasting impact of childhood SEP on adult health and socioeconomic conditions (Case et al., 2005). It is nevertheless unclear how childhood SEP relates to *subjective* SEP. Could it be that childhood SEP also determines adult subjective SEP, through some sort of class consciousness?

In this paper, we have estimated respondents' implicit importance

Table 2
Comparisons on subjective SEP scores between Australia and Norway, mean (SD).

	Subjective SEP		
	Australia	Norway	T test *p* value
Total	5.8 (2.0)	6.2 (2.1)	***
Sex			
Women	5.6 (1.9)	6.0 (2.1)	***
Men	5.9 (2.1)	6.4 (2.0)	***
Education			
Primary education <10 yrs	4.9 (2.0)	4.8 (2.4)	
Upper secondary	5.6 (2.0)	5.6 (2.1)	
Undergraduate	6.3 (1.7)	6.3 (1.7)	
Postgraduate	6.8 (2.1)	7.0 (1.9)	
Household income			
Low	4.8 (2.1)	5.3 (2.6)	***
Lower middle	5.3 (2.0)	5.9 (2.0)	***
Middle	5.9 (1.7)	6.3 (1.7)	**
Upper middle	6.6 (1.8)	6.7 (1.5)	
High	7.0 (1.7)	7.3 (1.6)	*
Occupation			
Not in labour force	4.9 (2.1)	4.9 (2.2)	
Other professions	5.7 (1.9)	6.1 (1.9)	***
Managers & professionals	6.6 (1.8)	7.3 (1.7)	***
Childhood financial circumstances			
Difficult	5.2 (2.0)	5.6 (2.3)	***
Neither good nor bad	5.6 (1.9)	5.9 (1.9)	***
Good	6.1 (1.8)	6.3 (1.8)	*
Very good	6.7 (2.5)	7.3 (2.1)	***
Parents' education			
Mother: Lower than tertiary	5.6 (2.0)	6.0 (2.0)	***
Mother: Tertiary education	6.6 (2.1)	6.6 (2.1)	
Father: Lower than tertiary	5.5 (2.0)	5.9 (2.0)	***
Father: Tertiary education	6.4 (2.1)	6.6 (2.1)	*

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *p* values were calculated based on independent samples *t*-test, with a 5% significance level. Standard deviations (SD) in parentheses.

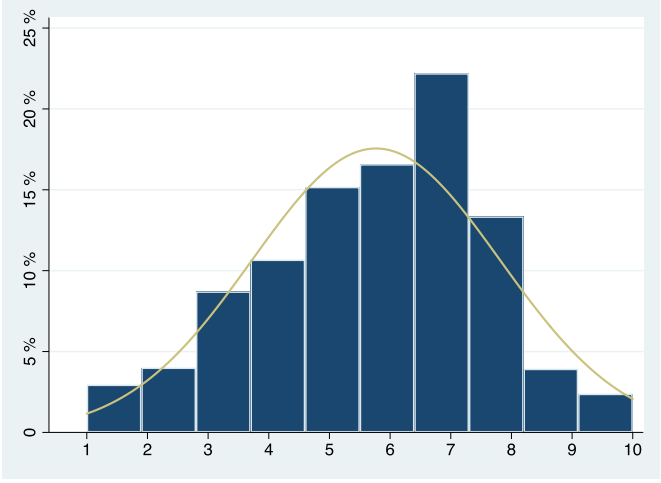

Fig. 1a. Distribution of respondents across the rungs of the subjective SEP ladder, Australia.

weighting of their own education, occupation and income in explaining subjective SEP, and compared two different countries to assess whether the relative importance of the determinants of subjective SEP vary with the institutional setting. We further expanded the analysis by assessing the relative importance of childhood SEP (CFC and parents' education). We found support for the hypothesis that childhood SEP has a lasting impact on individuals' subjective SEP, independent of their education, occupation and income, as also reported in Ferreira et al. (2018). Therefore, we theorise that the pathway from childhood SEP to adult health may pass through subjective SEP, independently of adult

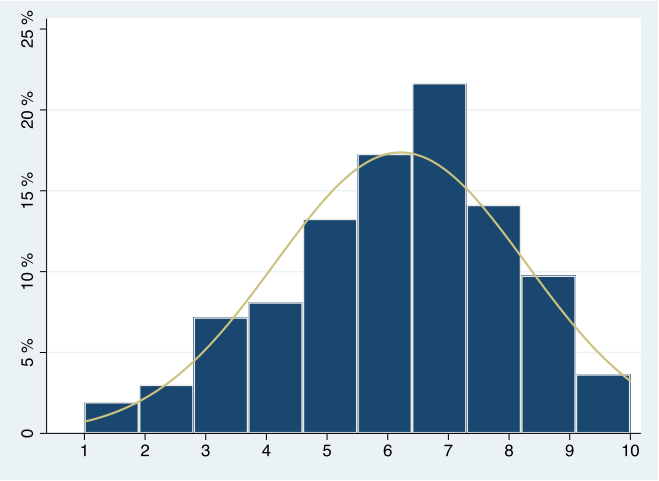

Fig. 1b. Distribution of respondents across the rungs of the subjective SEP ladder, Norway.

objective SEP.

The comparison of Australia and Norway suggests some striking differences in the relative importance of subjective SEP determinants between the two countries. In the Australian sample, income was the most important determinant (Fig. 2), possibly attributed to institutional differences, such as income inequality, partly as a result of different redistributive policies. Income inequality is higher in Australia than in Norway, and it is especially the top share of Australian earners that has 'taken off' in the past few decades (OECD, 2018b). In Norway, the relatively small income inequalities can be partly explained by a system of collective bargaining between employers and labour unions, ensuring wage coordination and compression across the occupational hierarchy (Barth et al., 2014). The combination of these factors could imply that Australia has larger inequalities in what money do for people's perception of their own SEP.

For example, it is more common in Australia that children from high-income families attend private schools, often associated with prestige and high-quality teaching. Income inequalities could, therefore, directly influence educational inequalities in Australia. This would suggest that the *type* of school seems to be more important than the number of years spent in school. In Norway, private schools are not common, and which school people went to is less likely to influence their subjective SEP. Rather, university-level education is a potential ticket to higher social standing. This is arguably due to Norwegian education policy that incentivises completing upper secondary school by offering universal access to higher education. This has led to an increased uptake of higher education by the population, which over time is likely to dilute the impact of higher education on subjective SEP. Additionally, this has created a highly merit-based education system that could make it increasingly difficult for those who do not have higher education to enter the labour market (Mackenbach, 2012).

In the Norwegian sample, occupation was the most important predictor of subjective SEP. The occupation variable indicated two things: those in managerial positions reported a significantly higher subjective SEP, and being outside of the labour force was a major determinant for lower subjective SEP. This could be linked to the previous point about those without higher education; indeed, respondents with only primary education were overrepresented among those outside of the labour force. A central welfare policy goal in Norway has been to stimulate people to work rather than to provide disability benefits or social security. Policies are, therefore, meant to ensure high labour force participation and advantages to work (Meld. St. 46. (2012–2013)). Our results point to a potentially unintended consequence of this policy: that those who for whatever reason do not work are stigmatised, reflecting

Table 3
Ordinary least squares regression results explaining subjective SEP, Australia and Norway.

	A		B		C	
	Australia	Norway	Australia	Norway	Australia	Norway
Education (ref. upper secondary)						
Primary education <10 yrs	−0.51*** (0.14)	−0.86*** (0.24)	−0.45*** (0.14)	−0.66*** (0.24)	−0.45*** (0.13)	−0.63*** (0.24)
Undergraduate	0.43*** (0.13)	0.58*** (0.13)	0.28** (0.13)	0.49*** (0.13)	0.25* (0.13)	0.42*** (0.12)
Postgraduate	0.84*** (0.17)	1.15*** (0.13)	0.58*** (0.17)	0.65*** (0.14)	0.39** (0.17)	0.44*** (0.13)
Household income (ref. low)						
Lower middle	0.45*** (0.16)	0.51*** (0.17)	0.41*** (0.16)	0.35** (0.17)	0.47*** (0.15)	0.45*** (0.16)
Middle	0.90*** (0.16)	0.79*** (0.19)	0.77*** (0.16)	0.59*** (0.19)	0.81*** (0.16)	0.69*** (0.18)
Upper middle	1.53*** (0.16)	1.16*** (0.17)	1.35*** (0.17)	0.92*** (0.18)	1.33*** (0.17)	1.04*** (0.17)
High	1.98*** (0.19)	1.64*** (0.18)	1.78*** (0.20)	1.27*** (0.19)	1.75*** (0.19)	1.28*** (0.18)
Occupation (ref. other professions)						
Not in labour force			−0.24* (0.13)	−0.74*** (0.16)	−0.21 (0.13)	−0.71*** (0.15)
Managers & professionals			0.42*** (0.13)	0.79*** (0.12)	0.37*** (0.13)	0.62*** (0.12)
Childhood financial circumstances (ref. neither good nor bad)						
Difficult					−0.26** (0.12)	−0.06 (0.15)
Good					0.39*** (0.12)	0.38*** (0.11)
Very good					0.74*** (0.20)	1.18*** (0.16)
Parents' education (ref. lower than tertiary)						
Mother's tertiary education					0.34** (0.15)	0.30** (0.12)
Father's tertiary education					−0.13 (0.14)	−0.03 (0.12)
Demographic characteristics						
Age (yrs.)	0.02*** (0.00)	0.02*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.02*** (0.00)	0.02*** (0.00)
Male	0.12 (0.10)	0.03 (0.10)	0.06 (0.10)	−0.02 (0.10)	0.01 (0.10)	−0.08 (0.09)
Constant	4.05*** (0.22)	4.23*** (0.19)	4.30*** (0.24)	4.73*** (0.22)	3.91*** (0.25)	3.97*** (0.24)
Observations	*1422*	*1393*	*1422*	*1393*	*1422*	*1393*
R^2	*0.19*	*0.21*	*0.20*	*0.26*	*0.23*	*0.30*

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The undergraduate and post-graduate education levels correspond to university education up to four years, and university education of four years or more, respectively. Robust standard errors in parentheses. Sampling weights in both countries included.

negatively on people's perceived SEP. In the Australian sample, those outside of the labour force also reported a lower subjective SEP, but of a smaller magnitude.

Analysing education, occupation and income as predictors of subjective SEP resulted in an R^2 of 20% and 26% in Australia and Norway respectively (Table 3, Model B). Considering that the MacArthur scale is framed in terms of education, income and occupation, a larger proportion of explained variation could be expected. At the same time, this could limit respondents' conception of their subjective SEP (Navarro-Carrillo et al., 2020), but our data indicate that respondents included other factors when assessing their subjective SEP. Childhood SEP seems to constitute some of these factors.

In the Australian sample, reports of *difficult* or *very difficult* CFC were significantly associated with lower subjective SEP. In the Norwegian sample, this association was not significant, which could suggest that institutions, such as the school system, provide similar opportunities for children regardless of different social backgrounds. Conversely, those who reported very good CFC had a significantly higher subjective SEP. The magnitude was largest in the Norwegian sample wherein respondents reported more than one rung higher on the subjective SEP ladder. This coefficient was larger than that for the highest income level, suggesting that being raised in prosperous circumstances could contribute to a higher status than living in a high-income household. The *very good* coefficient was smaller among Australian respondents, although significantly higher than the reference. These results could imply that people's subjective SEP is internalised in childhood and that this 'class consciousness' remains an integral part of individuals' understanding of where they belong in the social hierarchy. Parents' education had limited independent association with respondents' reporting of subjective SEP, but it still confirmed the importance of mother's education in influencing subjective SEP in adulthood in both samples. This is in line with we found that mother's education was more important than father's, in line with previous findings (see e.g., Chen & Li, 2009).

It should be noted that the CFC question can be perceived and recalled differently according to contextual and cultural factors. However, CFC has previously been found to perform well in proxying childhood SEP when parents' income records are unavailable (Straughen et al., 2013), and has been widely used (see e.g., Luo & Waite, 2005), also in cross-country studies (Listl et al., 2018). CFC could possibly depend on age, but it was only *good* CFC in the Australian sample that interacted with age. Interaction analyses of sex did however indicate that Norwegian women responding *very good* CFC were more likely to report higher subjective SEP than men.

Other significant interactions for sex in the Norwegian sample was income, favouring men in terms of subjective SEP, potentially due to a larger proportion of men reporting higher income brackets. Highly educated women seemed to benefit more in terms of subjective SEP than men. In the Australian sample, men in the upper-middle income category reported higher subjective SEP than women. Age interacted significantly with the upper education levels and all income categories.

Considering the analysis of age, in the Australian sample, including a quadratic age term to Model C indicated that there was a negative association with subjective SEP for those in early adulthood, but the association turned positive and nearly linear for older respondents. Overall, the results remained largely the same, and for comparison purposes we only kept the linear age term in the main analyses.

The paper's full model explained 23% and 30% of the variance in subjective SEP in Australia and Norway, respectively. As indicated above, there are a range of other potential factors not measured in this survey that could explain subjective SEP. One such factor could be accumulated wealth, which could be an even stronger predictor than occupation and income. This is likely to depend on age, since older people have more accumulated wealth, which could explain why we found that subjective SEP was positively associated with age. This is in line with Andersson (2018), who suggested that wealth was the main predictor of high placements in the ladder, even for those who reported lower average levels of education, occupational prestige and income.

The current paper focuses on adults, but studying *adolescents'* perception of social stratification should be considered in future research, as this is an important development stage in the life course. The youth version of the MacArthur scale is warranted for such analyses (Goodman et al., 2001). In the context of this paper, the relative importance of childhood SEP would probably be greater for adolescents

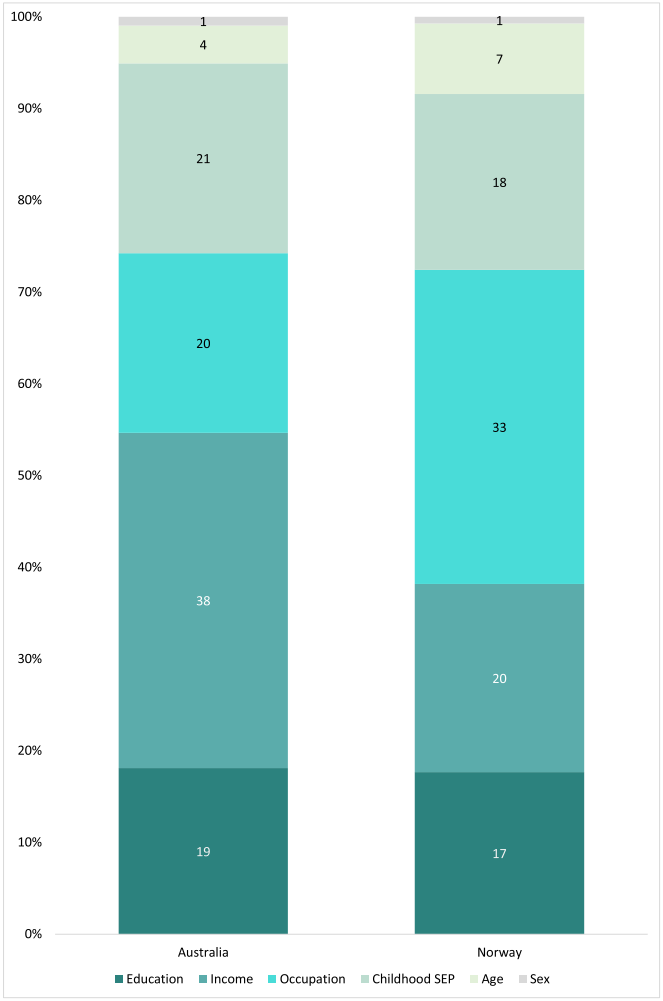

Fig. 2. Relative importance of determinants of subjective SEP as a proportion of the R^2, Australia and Norway, respectively. Each determinant's relative importance is reported as the percentage of the explained variance, R^2. Based on Shapley value decomposition of Model C in Table 3, in which a 100% corresponds to the models' R^2 (21% and 26% in the Australian and Norwegian samples, respectively). Determinants of subjective SEP: education, income, occupation and childhood SEP (childhood financial circumstances and parents' education), age and sex.

than for adults.

This paper has some limitations. First, there is a risk of selection bias due to the recruitment approach, even if age and sex quotas were applied. Online panels using sample quotas is nevertheless common practice in different health fields (see e.g., Lewis et al., 2016; Johnson et al., 2019), and online panels is considered a cost-effective means to achieve representative samples in a short period of time (Bansback et al., 2014). However, the samples might not be representative in terms of other factors, such as income or education. For example, postgraduates were overrepresented in both samples. Given that this study aimed to investigate the relative importance of each indicator, the overrepresentation of highly educated respondents was not a big concern. Moreover, the distribution of respondents across education levels differed between the two samples: the proportion of respondents with a postgraduate degree was twice as large in Norway as in Australia. This could explain why our data showed a general tendency of lower mean subjective SEP values in Australia than in Norway, since the mean values by the education level were nearly the same (Table 2). Second, we only reported the direct associations of the predictor variables with subjective SEP. Interaction analyses were conducted among the predictors, but we found no systematic tendencies. Interaction analyses of dummy variables are challenging, especially with relatively small samples. Third, the occupation variable is somewhat difficult to interpret, particularly the *not in labour force* category, as it does not distinguish between different reasons for not working. Ideally, this would be split since as different groups as students and unemployed people were analysed in the same group. Fourth, institutional and cultural differences could lead to systematically different interpretations of the subjective SEP question, which we did not account for.

5. Conclusions

This study provides new insights into respondents' implicit weighting of objective and childhood factors in predicting subjective SEP. We have estimated the contribution of each of the commonly used objective SEP indicators (education, occupation and income) in explaining subjective SEP. In addition, we have added childhood SEP as an important determinant of subjective SEP; while controlling for the objective SEP variables, we found that the influence of childhood SEP persisted into adulthood. We have further pointed to each of these components' relative importance in explaining subjective SEP. Lastly, we have demonstrated how the relative contribution of each of these determinants differs between two countries.

As for policy implications, this paper has shed light on the need for intervention in policy areas that would affect subjective SEP, such as reduced income inequalities (Australia) and improved social inclusion policies (Norway). However, considering the 'subjectiveness' of the concept, the evidence base for any policy intervention would need to complement findings like these with research on other endpoints, such as well-being and health outcomes.

Future research should further investigate the inconsistency between reported subjective and objective SEP. This could provide information on the characteristics of those who overreport or underreport their subjective SEP, as well as illuminate how subjective SEP is a construct distinct from objective SEP. From a health perspective, more research is needed on the pathway from childhood SEP to health via subjective SEP. Moreover, we need a better understanding of the specific mechanisms between objective and subjective SEP on the one hand, and social inequalities in health on the other, to better grasp the role of subjective SEP as a determinant of health inequalities.

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CRediT authorship contribution statement

Marie Hella Lindberg: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Roles/. **Gang Chen:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Resources. **Jan Abel Olsen:** Conceptualization, Writing – review & editing, Funding acquisition, Project administration, Resources, Supervision. **Birgit Abelsen:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Supervision.

Declaration of competing interest

None.

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Appendix

Table A.1
Descriptive statistics of original data of variables that were collapsed in the regression analyses.

	Australia						Norway					
	Female		**Male**		**Total**		**Female**		**Male**		**Total**	
Variables	**Mean/%**	**N**	**Mean/%**	**N**	**Mean/%**	**N**	**Mean/%**	**N**	**Mean/%**	**N**	**Mean/%**	**N**
Mother's education												
Primary education <10 yrs	60.5	442	56.4	390	58.5	832	35.0	198	37.6	313	36.5	511
Upper secondary	22.0	161	19.4	134	20.8	295	27.9	158	22.9	191	25.0	349
Undergraduate	9.9	72	13.9	96	11.8	168	15.2	86	17.4	145	16.5	231
Postgraduate	7.7	56	10.3	71	8.9	127	21.9	124	22.1	184	22.0	308
Father's education												
Primary education <10 yrs	56.1	410	46.9	324	51.6	734	31.3	177	28.9	241	29.9	418
Upper secondary	22.7	166	22.6	156	22.6	322	28.1	159	28.3	236	28.2	395
Undergraduate	13.1	96	17.2	119	15.1	215	14.8	84	18.6	157	17.2	241
Postgraduate	8.1	59	13.3	92	10.6	151	25.8	146	23.9	199	24.7	345
Occupational category												
Not in labour force	39.1	286	20.7	143	30.2	429	26.1	148	15.6	130	19.9	278
Machinery operators, drivers & labourers	3.4	25	10.4	72	6.8	97	10.9	62	13.3	111	12.4	173
Sales & service	27.0	197	15.3	106	21.3	303	28.6	162	28.5	237	28.5	399
Technicians & trade workers	3.6	26	15.6	108	9.4	134	10.2	58	11.0	92	10.7	150
Managers & professionals	27.0	197	38.0	263	32.3	460	24.2	137	31.6	263	28.6	400
Household income AUD							**Household income per 1000 NOK**					
<25,000	13.8	101	10.0	69	12.0	170	<349	26.1	148	15.3	127	19.6	275
25,001–35,000	10.7	78	10.7	74	10.7	152	350–499	18.0	102	14.5	121	15.9	223
35,001–50,000	15.2	111	12.0	83	13.6	194	500–699	16.2	92	15.1	126	15.6	218
50,001–65,000	10.9	80	11.4	79	11.2	159	700–849	11.6	66	13.2	110	12.6	176
65,001–85,000	11.4	83	10.1	70	10.8	153	850–999	11.6	66	14.7	122	13.4	188
85,001–100,000	10.0	73	10.1	70	10.1	143	1000–1199	7.1	40	10.0	83	8.8	123
100,001–130,000	11.8	86	14.3	99	13.0	185	1200–1399	5.1	29	7.4	62	6.5	91
130,001–160,000	7.3	53	10.3	71	8.7	124	>1400	4.2	24	9.8	82	7.6	106
160,001–220,000	6.6	48	7.8	54	7.2	102						
>220,001	2.5	18	3.3	23	2.9	41						

Table A.2
OLS analyses of Model C (Table 3) with age and sex interactions

	Australia		Norway
Education (ref. upper secondary)		Education (ref. upper secondary)	
Primary education <10 yrs	−0.47***">*** (0.13)	Primary education <10 yrs	−0.61**">** (0.23)
Undergraduate	0.96*** (0.33)	Undergraduate	0.42*** (0.13)
Postgraduate	1.32*** (0.46)	Postgraduate	0.75*** (0.17)
Household income (ref. low)		**Household income** (ref. low)	
Lower middle	−0.80* (0.48)	Lower middle	0.14 (0.21)
Middle	−0.36 (0.46)	Middle	0.30 (0.27)
Upper middle	−0.31 (0.48)	Upper middle	0.64*** (0.23)
High	−0.35 (0.54)	High	0.97*** (0.24)
Occupation (ref. other professions)		**Occupation** (ref. other professions)	
Not in labour force	−0.27** (0.13)	Not in labour force	−0.69*** (0.16)
Managers & professionals	0.34*** (0.13)	Managers & professionals	0.58*** (0.12)
Childhood financial circumstances (ref. neither good nor bad)		**Childhood financial circumstances** (ref. neither good nor bad)	
Difficult	−0.28** (0.12)	Difficult	−0.03 (0.15)
Good	1.43*** (0.32)	Good	0.36*** (0.11)
Very good	0.78*** (0.20)	Very good	1.67*** (0.22)
Parents' education (ref. lower than tertiary)		**Parents' education** (ref. lower than tertiary)	
Mother's tertiary education	0.33** (0.15)	Mother's tertiary education	0.31** (0.12)
Father's tertiary education	−0.20 (0.14)	Father's tertiary education	−0.01 (0.12)
Demographic characteristics		**Demographic characteristics**	
Age (yrs.)	0.01* (0.01)	Age (yrs.)	0.02*** (0.00)
Male	−0.15 (0.12)	Male	−0.51* (0.26)
Interactions		**Interactions**	
Age X Undergraduate education	−0.02** (0.01)	Male X Postgraduate education	−0.55*** (0.19)
Age X Postgraduate education	−0.02** (0.01)	Male X Lower middle income	0.83** (0.31)
Age X Lower middle income	0.02*** (0.01)	Male X Middle income	1.01*** (0.36)
Age X Middle income	0.02*** (0.01)	Male X Upper middle income	1.01*** (0.31)
Age X Upper middle income	0.03*** (0.01)	Male X High income	0.96*** (0.34)
Age X High income	0.03*** (0.01)	Male X Very good CFC	−0.91*** (0.27)

(*continued on next page*)

Table A.2 (*continued*)

	Australia		Norway
Education (ref. upper secondary)		Education (ref. upper secondary)	
Age X Good CFC	−0.02*** (0.01)		
Male X Upper middle income	0.53** (0.22)		
Constant	4.39*** (0.41)	Constant	4.07*** (0.27)
Observations	*1422*	*Observations*	*1393*
R^2	*0.25*	R^2	*0.32*

Note: *** p < 0.01, ** p < 0.05, * p < 0.1. There were no significant interactions with age in the Norwegian sample. The undergraduate and post-graduate education levels correspond to university education up to four years, and university education of four years or more, respectively. CFC: childhood financial conditions. Robust standard errors in parentheses. Sampling weights in both countries included.

Table A.3
Ordinary least squares analyses of Model C (Table 3) stratified by sex

	Australia		Norway	
	Female	Male	Female	Male
Education (ref. upper secondary)				
Primary education <10 yrs	−0.42** (0.18)	−0.49** (0.21)	−0.53 (0.33)	−0.74** (0.32)
Undergraduate	0.38** (0.17)	0.17 (0.19)	0.61*** (0.20)	0.20 (0.16)
Postgraduate	0.20 (0.23)	0.54** (0.25)	0.75*** (0.21)	0.13 (0.17)
Household income (ref. low)				
Lower middle	0.39** (0.20)	0.57** (0.25)	0.06 (0.22)	1.06*** (0.24)
Middle	0.74*** (0.20)	0.84*** (0.25)	0.20 (0.27)	1.43*** (0.25)
Upper middle	1.03*** (0.22)	1.60*** (0.26)	0.52** (0.24)	1.77*** (0.23)
High	1.50*** (0.27)	1.93*** (0.29)	0.84*** (0.25)	2.06*** (0.26)
Occupation (ref. other professions)				
Not in labour force	−0.05 (0.16)	−0.41* (0.22)	−0.86*** (0.23)	−0.41** (0.20)
Managers & professionals	0.60*** (0.19)	0.20 (0.17)	0.71*** (0.18)	0.51*** (0.16)
Childhood financial circumstances (ref. neither good nor bad)				
Difficult	−0.10 (0.16)	−0.46** (0.19)	0.06 (0.23)	−0.08 (0.18)
Good	0.26 (0.17)	0.51*** (0.17)	0.32* (0.17)	0.39*** (0.15)
Very good	0.89*** (0.26)	0.63** (0.30)	1.67*** (0.24)	0.71*** (0.21)
Parents' education (ref. lower than tertiary)				
Mother's tertiary education	0.32 (0.20)	0.35 (0.21)	0.39** (0.18)	0.28 (0.17)
Father's tertiary education	0.04 (0.20)	−0.30 (0.19)	−0.12 (0.18)	0.09 (0.15)
Age (yrs.)	0.02*** (0.00)	0.02*** (0.00)	0.02*** (0.01)	0.02 (0.00)
Constant	3.67*** (0.32)	4.13*** (0.39)	3.98*** (0.38)	3.66*** (0.29)
Observations	*731*	*691*	*566*	*827*
R^2	*0.22*	*0.25*	*0.38*	*0.27*

Note: *** p < 0.01, ** p < 0.05, * p < 0.1. The undergraduate and post-graduate education levels correspond to university education up to four years, and university education of four years or more, respectively. Robust standard errors in parentheses. Sampling weights in both countries included.

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Paper III

Lindberg MH, Wildman J, Abelsen B, Olsen JA.

The lasting impact of circumstances on efforts and health in adulthood.

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The lasting impact of circumstances on efforts and health in adulthood

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Abstract

A central policy goal in many countries is to reduce social inequalities in health. In the inequality of opportunity (IOp) framework, not all inequalities are necessarily illegitimate. Roemer's distinction between justifiable and illegitimate inequalities is based on individual responsibility: whether inequalities arise from factors beyond the individual's control (circumstances) or from factors that the individual can control (efforts). This paper aims to: i) identify the role of IOp in explaining health inequalities in an egalitarian country like Norway; and ii) assess how efforts predict change or maintenance of health. We use data on an adult sample (N=8,903, aged ≥32 at baseline) who participated in two waves of the Tromsø Study, a comprehensive health survey of the adult population of the Norwegian municipality of Tromsø, conducted in 2007/08 and 2015/16. As circumstances, we define childhood financial circumstances, education, height, parental somatic and mental health, parental substance abuse, age, and sex. Effort variables are body mass index, smoking, physical activity, and alcohol consumption. Outcomes are health-related quality of life (HRQoL), measured by the EQ-5D, and self-rated health. IOp in health is estimated and decomposed into the relative importance of sources of IOp. Ordinary least squares and fixed-effects panel regression analyses are used to analyse how efforts influence changes in and level of health, and the indirect influence of circumstances on health channelled through efforts. Childhood financial circumstances and education accounted for the largest proportion of IOp. Parental health also contributed substantially to IOp in HRQoL. Apart from education, there were limited indirect influences of circumstances via efforts on health. Changes in efforts had relatively limited effects on changes in health. Worsened efforts had a stronger influence on health than improved efforts. Our findings indicated that there were unfair inequalities in health, even in a population in 'egalitarian' Norway.

Keywords: Health inequality; Inequality of opportunity; Circumstances; Efforts

Introduction

There is a considerable literature applying the inequality of opportunity (IOp) framework in analyses of inequality in health (e.g., Davillas & Jones (2020); Rosa Dias (2009); Trannoy et al. (2010)). Building on the Roemer framework, the common denominator in this literature is that not all inequalities are necessarily deemed illegitimate – it depends on their sources (Roemer, 1998, 2002). Inequalities that arise from differences in *circumstances*, such as family background or ethnicity, are considered unfair because they originate from sources beyond the control of the individual. These are inequalities that should be compensated or mitigated by policy to 'level the playing field' (Jusot et al., 2013).

Inequalities resulting from *efforts* are considered 'acceptable' in this framework, because they arise from differences in individuals' actions, preferences and choices, factors over which the individual is in control (Roemer, 2002). In a health perspective, efforts are typically captured by health-related lifestyles, such as being physically active, having a healthy diet or refraining from smoking (Rosa Dias, 2009). In this literature, the distinction between circumstances and efforts is therefore based on individual responsibility. However, drawing this distinction is complicated by the hypothesis that efforts are partially determined by circumstances (Roemer, 1998; Rosa Dias, 2009).

There are two approaches in the measurement of inequality in the IOp literature: the *ex ante* and the *ex post* approach. The *ex ante* approach focuses on the opportunities that people face to realise good health, and therefore only considers inequality due to circumstances (Donni et al., 2014). The *ex post* approach considers differences in health outcomes between groups of individuals exerting the same level of effort. Put differently, there would be no IOp if those exerting the same level of effort achieve the same level of health (Aaberge et al., 2011; Donni et al., 2014; Fleurbaey & Peragine, 2013). The *ex post* perspective therefore also considers efforts in the estimation of IOp.

In Norway, the government has made it an explicit goal to reduce social inequalities in health based on equal opportunities to achieve good health (Meld. St. 20 (2006-2007), 2007). Norway has a relatively generous welfare state, with free access to higher education and a tax-financed national health service. Income inequality is considered low in an international context (OECD, 2023). These preconditions appear to be sufficient to level the playing field. Therefore, if inequality of opportunity in health is observed in a socially and economically advanced setting like Norway, IOp in health must be an omnipresent phenomenon.

In this paper, we use panel data from two waves of a Norwegian population cohort study to assess whether inequality of opportunity in health has a role in explaining health inequalities in an egalitarian country. First, we estimate *ex ante* inequalities in opportunity in health-related quality of life (HRQoL) and self-rated health (SRH), quantifying the contribution from circumstances, defined as sources of inequalities outside the control of the individual. Second, we assess the additional impact of efforts, factors that individuals are responsible for, on inequalities in health by estimating how efforts influence change, maintenance, and level of health between the two waves. Using the same data material, we extend the work by Berthung et al. (2022), by including efforts to the IOp analyses and taking advantage of observations at two time points. We exploit rich data material on respondents' parental health, socioeconomic information, and health-related behaviour variables. Lastly, we analyse IOp in HRQoL using the EQ-5D, a health outcome that is rarely applied in the IOp literature, except for Berthung et al. (2022).

Material and Methods

Data: The Tromsø Study

We used data from the Tromsø Study, a prospective cohort study of a general adult population based in the municipality of Tromsø. Tromsø is the largest city in Northern Norway with approximately 77,000 inhabitants. The current paper applied data from the sixth and seventh wave of the survey

(referred to as Tromsø 6 and 7), conducted in 2007/08 and 2015/16. We restrict our sample to these two waves because previous waves did not include the same amount of socioeconomic and health variables. In Tromsø 6, N=12,984 participated (attendance rate: 65.7%). In Tromsø 7, N=21,083 participated (attendance rate: 65.0%). A detailed description of the survey design is available elsewhere (Hopstock et al., 2022; Jacobsen et al., 2011). We included only respondents who participated in both waves: N=8,903. We further restricted the sample to include only non-missing values in the two outcome variables (HRQoL and SRH), resulting in N=8,086 for cross-sectional analyses of Tromsø 6; N=8,457 for cross-sectional analyses of Tromsø 7; and N=7,708 for panel analyses of both waves. This study is a part of a research project that was approved by the Regional Committee for Medical and Health Research Ethics Northern Norway (ID: 2019/607).

Health

We applied two different health outcomes: one that is widely applied in the IOp literature, SRH (see e.g., Kunst et al. (1995); Rosa Dias (2009)); and HRQoL, a much less commonly used measure in this literature. SRH is considered a consistent proxy for objective health measures, such as mortality (DeSalvo et al., 2006; Idler & Benyamini, 1997) and healthcare use (van Doorslaer et al., 2000), although concerns have been raised about the SRH measure potentially suffering from heterogeneous reporting and therefore introducing bias (Bago d'Uva et al., 2008). SRH is obtained from the question: *How do you in general consider your own health to be?*, rated as *Very bad*, *Bad*, *Neither good nor bad*, *Good*, or *Excellent*. Following the literature (e.g., Jones et al. (2014)), SRH was dichotomised with *good health* as the cut-off for the analysis.

We further applied HRQoL, measured by the EuroQoL generic instrument evaluating quality of life along five health-related dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression (EQ-5D) (Rabin et al., 2014). As such, it is a more comprehensive measure of health compared to the single-item SRH measure. In Tromsø 6, the 3-level (3L) version was applied, whereas

the 5-level (5L) version was used in Tromsø 7. In the absence of Norwegian EQ-5D value sets, we applied the UK value set for 3L (Dolan, 1997), and the English value set for 5L (Devlin et al., 2018). For the panel regression analyses, we used the UK crosswalk value set, which applies the 3L UK value set on the 5L version (van Hout et al., 2012). We applied these two outcomes to first, follow the large literature on IOp in SRH; and second, adding to this literature analysing the EQ-5D as a health outcome. We were therefore able to contrast the traditional, direct SRH measure with a multidimensional health outcome, indirectly assessing individuals' HRQoL.

Descriptions of predictor variables are included in Table 1. The choice of some of the predictors are further motivated below.

Table 1: *Overview of included predictor variables*

Circumstances

Circumstances are strongly shaped by childhood socioeconomic conditions and have been found to influence socioeconomic factors and health in later life (e.g., Case et al. (2005)). We included childhood financial circumstances (CFC), own education, height, parental health (somatic health, mental health, and substance abuse problems), sex, and age as circumstance variables since these are considered factors outside the control of the individual.

While own education was included as a circumstance, it can be argued that education should be classified as an effort variable, since it is largely the individual's effort that determines educational outcomes. However, education is heavily influenced by early-life and adolescent circumstances, and the more advantageous conditions during childhood, the better the individual will perform in school (Bartley, 2016). This favours the classification of education as a circumstance. Moreover, Davillas & Jones (2020) include education as a circumstance based on 18 as the age of responsibility, so that

schooling up to this age is outside the individual's control. The same argument is valid in a Norwegian context. It is therefore included as a circumstance.

Height was included as a proxy for birth weight and early life nutrition (Black et al., 2007; Case et al., 2005; Case & Paxson, 2008), and is as such indicative of a circumstance.

Acknowledging the potential for intergenerational transmission of health (Ahlburg, 1998), parental health was included as a circumstance, as in e.g., Jusot et al. (2013). Parental health was measured by three variables, each measured both for the respondent's mother and father: somatic health, mental health, and substance abuse problems. The somatic health categorisation reflects that having two or more diagnoses/conditions is a frequently used definition of multi-morbidity (Johnston et al., 2018).

Age and sex capture biological determinants of health, which are entirely outside the control of the individual. Both age and sex (gender) are listed as characteristics upon which discrimination is prohibited according to the Norwegian Equality and Anti-Discrimination Act (2018). This is also in line with Carrieri et al. (2020). Nonetheless, age and sex are sometimes analysed as demographic controls (Jusot et al., 2013). We still maintain that age and sex, as with studies including ethnicity, should be classified as circumstances, since inequalities arising from these factors, although being biological determinants, could be mitigated by policy. Regardless of the preferred way of analysing age and sex, we conducted decomposition analyses (see below) which allows the reader to consider IOp excluding age and sex.

Efforts

Effort variables are measured by lifestyle indicators and conceptualised as living healthy or making healthy changes to one's health and was measured by body mass index (BMI), smoking status, physical activity, and alcohol consumption.

Statistical analyses

We first estimated *ex ante* IOp arising from circumstances (Tromsø 7). We used a regression-based technique proposed by Juárez and Soloaga (2014), which produces an *ex ante* inequality estimate of the variation in health that is due to observed circumstances. We applied the variance explained by circumstances as the inequality measure for the continuous outcome, HRQoL, in line with Ferreira and Gignoux (2011). For the dichotomous SRH measure, we applied the dissimilarity index (D-index). The D-index reports the share of individuals that would need to be redistributed to achieve an equal proportion reporting *good/excellent* SRH across the distribution of circumstances (Paes de Barros et al., 2009). Bootstrapped standard errors with 500 replications for the IOp estimates were included. The underlying regression models for the IOp estimates were ordinary least squares (OLS) regression analysis for HRQoL and probit regression analysis for SRH. For SRH, we report the linear probability model (LPM) rather than the probit model, after confirming that the LPM coefficients are similar to the average marginal effects estimates, to ease interpretation. Next, we used Shapley value decomposition to identify the relative contribution of observable circumstances to IOp. This technique measures the marginal contribution to the model's explained variance by adding a given predictor to the model, weighted by the number of permutations represented by a sub-model that does not contain this predictor (Shorrocks, 2013).

Thereafter, we added efforts (BMI, smoking, physical activity, and alcohol consumption) to the analyses, thus taking the *ex post* approach. Since we focus on change and maintenance of both effort and health, the following analyses were either conducted using observations at follow-up (Tromsø 7), or panel data. We produced a transition probability matrix to demonstrate the probability of transitioning between the different categories of each of the effort variables, i.e., making changes or maintaining the level of exerted effort between the two time points (Tromsø 6 and 7).

Since the exertion of efforts is shaped by individuals' social background, we investigated whether there was any indirect influence of circumstances that was channelled through efforts. First, we ran a model with efforts (and age and sex) as the only regressors, demonstrating the direct influence of efforts on health. Second, we added circumstances to the model to investigate the indirect influence of circumstances on effort in predicting health. These results were compared to the main model with circumstance variables as the only regressors. This approach is similar to that applied by Rosa Dias (2009). We also decomposed the contribution from efforts versus that of circumstances. In supplementary analyses, we estimated how circumstances directly influenced each of the effort variables separately. Additionally, we tested interacting the circumstance and effort variables.

Lastly, we ran fixed-effects panel regression analyses to estimate the influence of the separate effort components in explaining change in health between Tromsø 6 and 7. To investigate whether this differs between reported CFC, we further split the sample into two: those reporting *very difficult* or *difficult* CFC in one group (*unfortunate* hereafter), and those reporting *good* or *very good* in another (*fortunate* hereafter).

All statistical analyses were conducted using Stata© version 17.0 (Stata Corporation, College Station, Texas).

Sensitivity analyses

We stratified the *ex ante* IOp analyses by sex and age groups (<55; 55-69; and ≥70) to assess whether the IOp estimates, underlying regression models and relative importance found in the main analysis differed according to these demographic factors. For the sex-stratified model, the parental mental health and substance abuse problems variables were split according to mother and father, to assess whether there were any sex- and parent-specific associations. Additionally, we ran analyses including maternal education as a circumstance, estimating IOp and relative importance. Maternal education

was also recorded as her highest attained education level out of four. Due to few respondents in the two post-secondary education categories, these were collapsed into one category for higher education.

The distribution of the EQ-5D-5L index score (HRQoL) was left-skewed. We therefore included unconditional quantile regression analyses based on the recentred influence function (RIF) approach (Firpo et al., 2009), investigating whether the contribution of circumstances differed across the HRQoL distribution in Tromsø 7. This was analysed with the user-written Stata command 'rifreg' (Fortin, 2018). For each quantile, we estimated IOp and the relative importance (Shapley decomposition).

Next, to complement the fixed-effects model, we ran a simpler model on the Tromsø 7 sample in which dummies for maintenance, worsening, or improvement of effort, given the level of effort in Tromsø 6, were applied as predictors for health. The 'healthiest' level of maintained effort was used as the reference for all effort variables.

Counterfactual analyses by means of Oaxaca decomposition (Oaxaca, 1973) were conducted to assess the extent of inequality in health between the fortunate and the unfortunate group, given similar level of efforts. This technique decomposes the gap between the two groups into the 'explained' and 'unexplained' effects. The explained effect is the proportion of the gap arising from differences in the exertion of effort and demographic characteristics. The unexplained effect captures the part of the gap that is due to the differences in the obtained 'returns' to observed efforts and demographic characteristics (Pagan, 2011). It produces an estimate of the change in the unfortunate group's health had they had the fortunate group's response to the same level of exerted effort.

Lastly, all the main cross-sectional analyses were rerun on the panel sample (N=7,708) to assess whether the results changed substantially from dropping these missing observations.

Results

Table 2 reports the summary statistics of the Tromsø 6 and 7 samples. Given that this dataset consists of a community sample, it is generally a healthy sample with a mean HRQoL of 0.86 (EQ-5D-3L) in Tromsø 6 and 0.90 (EQ-5D-5L) in Tromsø 7, higher than the mean value of 0.81 found by Garratt et al. (2022). There were 71.5 and 66.4% reporting good or excellent SRH in Tromsø 6 and 7, respectively. This was lower than what was found in the general population of 79% (Statistics Norway, 2020). Since the two HRQoL values are based on different versions (3L and 5L), the scale lengths are different. These are therefore not entirely comparable. When applying the 3L UK value set on the 5L version, the mean value (SD) was 0.83 (0.14). Own education is a variable that would be expected to remain similar between the waves. However, there was a larger proportion reporting primary education in Tromsø 7 than in Tromsø 6 (30% vs 24%, respectively).

***Table 2**: Summary statistics*

The change and maintenance of level of effort in the four effort variables between the two time points are reported in the appendix Tables A1 a-d).

Ex ante IOp

The *ex ante* IOp estimates and the underlying regression models are reported in Table 3. For HRQoL, the variance inequality measure is 0.034. I.e., 3.4% of total inequality can be attributed to circumstances. For the dichotomous SRH, the D-index indicates that 7.0% of respondents reporting good/excellent health would need to be 'reallocated' to individuals who report poorer health (lower than *good*) to achieve equality of opportunity in health. The underlying regression models for the IOp estimates report a consistently negative association for those reporting (*very*) *difficult* CFC for both

outcome measures. E.g., HRQoL is 0.02 lower for those reporting (*very*) *difficult* CFC, relative to those reporting *good* CFC. The probability of reporting *good* or *excellent* SRH is 0.08 lower for those reporting (*very*) *difficult* CFC. This model also suggests a clear education gradient. Having a parent with two or more somatic diseases and a parent with mental health problems had a significantly negative influence on both health outcomes. Having a parent with substance abuse was significantly and negatively associated only with HRQoL. The age group coefficients indicate that the older respondents have worse health than their younger counterparts. Male respondents had significantly better HRQoL than women, but there were no significant sex differences in SRH.

***Table 3**:* Ex ante *inequality of opportunity (Tromsø 7)*

These sex differences were also apparent when inspecting the relative importance of sources of IOp: for HRQoL, sex explains 26% of all variation, whereas this was only 2% for SRH (Figure 1). It was mainly CFC and own education that stood out as key drivers of IOp. For SRH, own education contributed with nearly half of the variation. Parental health variables, especially mental health problems, mattered more for HRQoL than SRH (19% vs 8% in total).

***Figure 1**: Shapley decomposition of* Ex ante *inequality of opportunity*

Analyses split by sex are reported in the appendix Table A2. We found larger IOp estimates for women than for men for both outcomes. The model including mother's education is reported in appendix Table A3, with no or limited added contribution to the models. For age group differences, it was especially the relative importance of own education that varied greatly (appendix Table A4 a-b).

The unconditional quantile (RIF) regression of HRQoL indicated that IOp in HRQoL due to circumstances and their relative importance varied across quantiles: the IOp estimates were smallest in the 10th quantile (0.02) and largest in the 50th (0.04) (see appendix Table A5 and Figure A1).

Ex post IOp

Adding efforts to the analyses, we compared the direct influence of efforts on health with a model including the indirect influences of circumstances (Table 4). These results are also compared to the results in Table 3 reporting the direct influence of *circumstances* on health. All effort coefficients remain statistically significant after the inclusion of circumstances, with slightly attenuated associations. For HRQoL, these changes are only at the third decimal, while the reductions are somewhat larger for SRH. Compared to the model in Table 3, most circumstance coefficients remained statistically significant. Own education was an exception, for which it was only the highest education level that was significantly associated with HRQoL. For both outcomes, the education coefficients were smaller, which could suggest that it is education that has the largest indirect contribution via efforts. This was corroborated by the model estimating the direct influence from circumstances on separate effort variables, with an education gradient in all effort outcomes (appendix Table A6). For the other circumstances, these results indicate that a small portion of their influence on health is channelled through efforts, but the majority seems to be a direct association. The relative importance of efforts was smaller than that of circumstances for HRQoL, while the opposite was true for SRH. In terms of interaction analyses, there were some significant circumstance and effort interactions, but without any clear pattern (output not reported).

***Table 4**: Direct influence of efforts and indirect influence of circumstances on health (Tromsø 7)*

Table 5 a) reports the results of fixed-effects panel regression models of the separate effort variables on health. For HRQoL, it was only BMI ≥30 that was significantly associated with a lower HRQoL,

compared to the normal weight category. For SRH, the less physically active, and the higher the BMI, the lower the probability of reporting *good* or *excellent* health.

***Table 5 a)**: Fixed-effects panel regression of efforts on health*

We also estimated models with dummies for efforts and found similar patterns (see appendix Table A6).

With the sample split into *unfortunate* vs *fortunate* in Table 5 b), it was primarily the *fortunate* group that seemed to be driving the findings in Table 5 a) through the influence from weight gain (both outcomes) and reduced physical activity (SRH). The F statistic of the overall model fit for the *unfortunate* group was insignificant in both outcomes.

***Table 5 b)**: Fixed-effects panel regression of efforts on health,* unfortunate *vs* fortunate

The Oaxaca decomposition of mean differences in health due to exerted efforts, age, and sex, between the *unfortunate* and *fortunate* groups are reported in appendix Table A8, in which we found that it was the unexplained part that was the largest contributor to the difference between the two groups in both outcomes.

Appendix Tables A9-A10 and Figure A2 using the panel sample (N=7,708) reproduce the models in Tables 3-4 and Figure 1 without substantial deviations.

Discussion

The aim of this paper was to investigate whether IOp in health has a role in explaining inequalities in two health outcomes: health-related quality of life and self-rated health, in 'egalitarian' Norway. We

further set out to assess the additional influence of efforts on inequality in health, both cross-sectionally, and in a panel framework. Our findings did suggest an existence of IOp in health. We found positive associations between healthy behaviours and health in cross-sectional analyses. Panel analyses suggested that putting effort into improving one's health had a somewhat limited influence on *improved* HRQoL and SRH, while worsened efforts indicated negative changes in health.

Ex ante IOp

In the context of equality of opportunity, Norway would be expected to be a 'best case' due to relatively high scores on social and economic parameters: it is a country with low income inequalities, high GDP per capita, free access to all levels of education, and a healthy population. Yet, substantial health inequalities have been documented, e.g., in life expectancy (Kinge et al., 2019; Steingrímsdóttir et al., 2012) and cause-specific mortality (Strand et al., 2014). This is in line with the so-called 'Nordic paradox', that countries with generous welfare regimes still experience substantial inequalities in health (Mackenbach, 2012). It is therefore unsurprising that this study revealed IOp in health, as indicated by the *ex ante* results. Observable circumstances accounted for approximately 3.4% of inequalities in HRQoL. For SRH, this was 7%, which is of similar magnitude as those found in other countries, e.g., for SRH in the UK: ranging from 5-10% (Jones et al., 2014), although the set of included circumstances was different. While estimated IOp in HRQoL is relatively modest, these findings would imply that even in Norway, with its comprehensive welfare state, achieving IOp in health is a complicated task.

Our results suggested that CFC, as well as own education, were key determinants of these inequalities. This corroborates previous literature on the role of early-life circumstances, e.g., Case et al. (2005). Additionally, for HRQoL, the combined contribution of parental health indicated intergenerational transmission of health, as found in Trannoy et al. (2010). The analyses split by sex revealed certain noticeable differences in HRQoL: CFC was substantially more important for women while the

combined importance of parental health was evident for men. In terms of age groups, the importance of own education declined with age for both outcomes. This is likely not due to age per se, but a consequence of higher education becoming increasingly common among larger proportions of the population over the past generations (Chen et al., 2013).

It is common to include parental education in analyses of IOp in health (e.g., Davillas & Jones (2020); Rosa Dias (2009)). Especially maternal education has been found to be an important determinant of her descendant's health (Chen & Li, 2009; Currie & Moretti, 2003). However, we did not include maternal education as a circumstance in the main analyses, due to small or negligible contributions to the models.

Analyses beyond the mean (RIF regression) indicated considerable variation in how circumstances related to HRQoL. The stronger associations of circumstances in the lower parts of the distribution could indicate that the impact of unfavourable circumstances was stronger than that of advantageous circumstances. However, the relative importance of CFC nearly doubled from the 10^{th} to the 75^{th} quantile, and it was mainly those reporting difficult CFC that drove the overall relative contribution of CFC (not reported). These analyses suggest that the mean-based results masked important insight into the role of circumstances in HRQoL.

Ex post IOp

Adding efforts to the analyses, to estimate the 'true' influence from efforts on health, it is necessary to consider the indirect effect of circumstances (Roemer, 1998). Our results suggested that it was primarily education that had an indirect influence through efforts. Education is different from the other 'early-life' circumstances, in that it is more proximate in time, and it involves a degree of effort. E.g., education is in some literature considered a proxy for productivity (Grossman, 1972), which could

suggest that the higher educated are more efficient in 'producing' health. This might explain why education had the strongest indirect impact on health.

The fixed-effects analyses indicated a somewhat limited influence from putting an effort into improved health between the two time points, although weight gain and physical inactivity was significantly associated with lower SRH. However, since only observations that change between the waves will appear in the model, no change does not necessarily indicate that healthy efforts do not influence health. Moreover, these 'unexpected' results could be due to the subjectiveness of the self-reported measures, i.e., that some unhealthy behaviours incur pleasure leading to more favourable assessments of health (Bombak, 2013). Of the included effort variables, it could be that a high BMI (obesity) is the most likely to negatively influence individuals' quality of life (Fontaine & Barofsky, 2001), which could explain our findings for HRQoL. The period between the two waves of eight-nine years might also be too short to drastically influence health. Lastly, the respondents are in their mid- to late life, and behaviour change might be more difficult to commit to after lifestyles have established, which might be more likely the higher the age.

The model split by unfortunate and fortunate CFC revealed that it was primarily the fortunate group that contributed to the 'origin' of the results for the full sample. This was corroborated by the model including dummies for change and maintenance of efforts: worsening or maintaining unhealthy efforts were significantly associated with a lower reporting of both outcomes, which was not compensated by an equivalent improvement in efforts, relative to those who maintained healthy efforts. Combined, these results indicate that, for those in unfortunate circumstances and poor health, exerting positive effort would not significantly improve health. A potential explanation is that the unfortunate might be less efficient in translating efforts into good health, whereas the fortunate and higher educated individuals are more 'efficient producers of health' (Grossman, 1972) through efforts and therefore benefit more from behaviour change. Thus, for those in good health, there seemed to be health to

lose by engaging in bad health behaviours. This could partly explain why many public health programmes aiming to reduce inequalities in health rather exacerbate them: they fail to take into account the structural causes of a clustering of unhealthy lifestyles in lower socioeconomic groups (Baum & Fisher, 2014).

It is worth mentioning that we found the opposite picture for alcohol, for which an increased and stable alcohol consumption was associated with a higher reporting of health (appendix Table A6). This is consistent with a common finding, that light to moderate alcohol consumption is associated with better health, e.g., in SRH (Gémes et al., 2019) and HRQoL (Kim & Kim, 2015; Valencia-Martín et al., 2013). It could be that the pleasure accompanying a moderate alcohol intake tap into the mental aspects of the two health outcomes, operating through different channels than objective health outcomes would.

The rationale for the use of two outcome measures (HRQoL and SRH) is based on the traditional use of SRH in the IOp literature and to explore the use of the EQ-5D (HRQoL). We found certain striking differences between these two measures, especially in terms of the relative importance of CFC and education, suggesting that they reflect distinct dimensions of health. While the EQ-5D suffered from skewedness, we have reported how estimates differ across quantiles, providing a more complete overview of the differential influence across the HRQoL distribution.

Contributions and limitations

In this paper, we add to the literature with results on IOp in health in a Norwegian cohort. First, we introduced an outcome measure that is not commonly utilised in the IOp literature: HRQoL measured by the EQ-5D, while also applying the conventional SRH measure. Second, we identified illegitimate inequalities arising from circumstances. The fact that we identified IOp in health in an egalitarian country like Norway suggests that there is a long arm of childhood circumstances and that inequalities

in health must be as good as omnipresent. Third, CFC and own education were identified as key contributors to IOp. Age and sex also accounted for large shares of variation. This study is not unique in identifying large relative contributions from age and/or sex: in Davillas and Jones (2020), age and sex combined accounted for the largest share of the variation in biomarkers. Intervening on the 'right' determinant of IOp remains a question of priorities, and our results clearly indicate that early childhood factors should be targeted. Fourth, while most policy efforts and public health campaigns target individual behaviour change rather than the structural factors that create health inequalities, we found that behaviour change seems to have limited impact on health. However, the limited influence from healthy changes in efforts on health could partly be due to maintenance of effort over time, which is not necessarily an indication of bad health behaviour.

As for policy implications, our results call for policies targeting the structural determinants of health. However, even with comprehensive welfare policies, health inequalities persist in Norway, partly because they favour the better off in society (Dahl et al., 2014). Our findings suggest that early-life interventions should be prioritised. Examples of recommended actions are to raise child benefits and to facilitate nursery enrolment (Arntzen et al., 2019). Education is an institution with the potential to reduce IOp in health. Norway has seen widened socioeconomic inequalities in academic performance (Dahl et al., 2014), indicating that educational policies should receive high priority to reduce the importance of education as a social 'stratifier'. Circumstances are largely determined by parental factors, highlighting the need to also focus on policies preventing IOp being transmitted across generations.

Some limitations must be acknowledged. First, we only included respondents taking part in both Tromsø 6 and 7, which means that the sample might not be representative. Moreover, the Tromsø Study is likely not representative of the Norwegian population since the population of Tromsø is slightly more urban and higher educated than the general population. Second, all the circumstance

variables, except for height, is self-reported at the time of the surveys. Some of these responses might therefore suffer from inaccurate recall. Third, the IOp estimates are lower-bound results of actual IOp as we included only *observed* circumstance variables. This could underestimate IOp. The same goes for the role of efforts – with more effort variables we would be able to produce more precise estimates. However, the results are still indicative of inequalities that must be considered by policymakers addressing the increasing health inequalities in Norway (Kinge et al., 2019; Steingrímsdóttir et al., 2012; Strand et al., 2014). Fourth, when studying change over time, it would be valuable to have a longer observation period and observations from more than two time points.

In conclusion, we have added insights into inequalities in opportunity health in a Norwegian cohort, identifying IOp in health in an egalitarian country like Norway, of which CFC and education were the key drivers. Future research should further assess the role of circumstances by linking to registers on parental occupation, income, and health outcomes. Moreover, investigating the role of efforts is a complex exercise, given the difficulties in achieving 'true' responses. Lastly, the identified main determinants of IOp are factors that can be intervened on and should be emphasised in investigating the potential of policy to mitigate the negative impact of adverse circumstances on health.

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Tables and figures

Table 1: Overview of included predictor variables

Variable name	Variable description/survey question	Manipulation if any	Categorisation	Final coding
Circumstances				
Childhood financial circumstances[a]	How was your family's financial situation during childhood?	Collapsing *very difficult* and *difficult*	Very good Good Difficult Very difficult	(Very) difficult (0) Good (1) Very good (2)
Own education[b]	What is the highest level of education you have completed?		Primary education <10 years Upper secondary and vocational school <4 years of higher education ≥4 years of higher education.	Primary education (0) Upper secondary/ vocational (1) Higher education <4 yrs (2) Higher education ≥4 yrs (3)
Height	Height in cm at time of attendance Tromsø 7	Standardised by 5-year age groups	Lowest 20 % Normal height 60 % Tallest 20 %	Low (0) Normal (1) Tall (2)
Maternal somatic health	Does your mother have or have had any of the following diagnoses/conditions: breast cancer; colon cancer; myocardial infarction before the age of 60; angina; cerebral stroke/brain haemorrhage; asthma; or diabetes	Combining all conditions into number of somatic conditions		None (0) One condition (1) Two or more (2)
Paternal somatic health	Does your father have or have had any of the following diagnoses/conditions: prostate cancer; colon cancer; myocardial infarction before the age of 60; angina; cerebral stroke/brain haemorrhage; asthma; or diabetes			None (0) One condition (1) Two or more (2)

Parental mental health	Mother/father has (had) psychological problems	Combining maternal and paternal mental health		No (0) Yes, one or both parents (1)
Parental substance abuse	Mother/father has (had) problems with substance abuse	Combining maternal and paternal substance abuse		No (0) Yes, one or both parents (1)
Age[c]	Age per 31.12.2015	Continuous, categorised into age groups		40-69 (0) 70-79 (1) ≥80 (2)
Sex				Women (0) Men (1)
Efforts				
Body Mass Index (BMI)	Combination of height and weight: Kilograms/metres^2	Continuous, categorised into four	Normal weight: BMI <25 Low overweight: 25-27.49 High overweight: 27.5-29.9 Obese: ≥30	Normal weight (0) Low overweight (1) High overweight (2) Obese (3)
Smoking	Do you/did you smoke daily?		Never Yes, now Yes, previously	Not currently smoking (0) Yes, now (1)
Physical activity	How often do you exercise (i.e., walking, skiing, swimming, or training/sports)? For how long time do you exercise (give an average)?	Combined and categorised into physical activity per week in minutes	Inactive: <60 Moderately active: 60-149 Active: ≥150	Inactive (0) Moderately active (1) Active (2)
Alcohol consumption	How often do you usually drink alcohol?	Collapsing *Never* and *Monthly or less frequently*; and *2–3 times /week* and *≥4 times /week*	Never Monthly or less frequently 2–4 times /month 2–3 times /week ≥4 times /week	Infrequent drinkers (0) 2-4 times /month (1) Regular drinkers (2)

[a]The reporting of *very good* and *good* childhood financial circumstances (CFC) differed somewhat between Tromsø 6 and 7. CFC was coded as *good* if respondents reported *good* in either Tromsø 6 or Tromsø 7.
[b]Vocational school was originally a separate category in Tromsø 6. This was collapsed with the upper secondary category.
[c]Age was only analysed cross-sectionally in the Tromsø 7 sample.

Table 2: Summary statistics

	Tromsø 6 (2007/08)		Tromsø 7 (2015/16)	
	Proportion/ mean	**N**	**Proportion/ mean**	**N**
Health-related quality of life (SD): EQ-5D (UK/English value set)	0.86 (0.18)	8,086	0.90 (0.11)	8,457
Self-rated health				
Very bad/bad	3.8	305	5.1	430
Neither good nor bad	24.7	1,999	28.6	2,415
Good	54.5	4,407	53.3	4,505
Excellent	17.0	1,375	13.1	1,107
Circumstances				
Age				
Years (SD)	55.5 (11.2)	8,086	63.6 (11.1)	8,457
30-39	3.4	273	-	-
40-49	31.2	2,519	13.7	1,155
50-59	21.9	1,771	25.3	2,135
60-69	33.1	2,673	26.5	2,238
70-79	9.7	780	27.4	2,315
≥80	0.9	70	7.3	614
Women	52.8	4,267	53.5	4,526
Men	47.2	3,819	46.5	3,931
Height in centimetres (SD)	170.3 (9.3)	8,081	169.6 (9.5)	8,433
Height (age-standardised)				
20 % lowest	20.7	1,840	20.7	1,844
60 % 'normal' height	59.2	5,268	58.8	5,233
20 % tallest	20.1	1,789	20.2	1,796
Childhood financial circumstances				
Difficult/very difficult	-	-	33.9	2,859
Good	-	-	58.2	4,915
Very good	-	-	8.0	671
Mother's education				
Primary education	77.8	6,125	81.4	6,718
Upper secondary	16.1	1,267	12.7	1,046
Higher education	6.1	481	5.9	486
Own education				
Primary education <10 years	23.6	1,896	30.2	2,492
Upper secondary	34.3	2,752	28.2	2,330
Higher education <4 yrs	19.7	1,578	18.2	1,505
Higher education ≥4 yrs	22.4	1,798	23.3	1,923
Parental somatic health				
Mother: 0	-	-	58.8	4,970
Mother: 1	-	-	30.3	2,561
Mother: ≥2	-	-	11.0	926
Father: 0	-	-	50.0	4,225
Father: 1	-	-	34.8	2,940
Father: ≥2	-	-	15.3	1,292
Parental mental health: No	-	-	90.3	7,640

Yes	-	-	9.7	817
Parental substance abuse: No	-	-	94.2	7,964
Yes	-	-	5.8	493
Efforts				
Weight (kg; SD)	78.0 (14.9)	8,081	78.9 (15.4)	8,435
BMI (SD)	26.8 (4.2)	8,081	27.3 (4.4)	8,432
BMI categories				
<25	35.5	2,867	31.6	2,660
25.0-27.49	25.9	2,092	24.8	2,090
27.5-29.9	19.3	1,559	20.3	1,710
≥30	19.3	1,557	23.3	1,965
Smoking				
No/previously	82.4	6,605	88.0	7,377
Yes	17.6	1,407	12.0	1,005
Physical activity				
Inactive (<60 min/week)	37.7	2,872	33.4	2,769
Moderate (60-149 min/week)	31.3	2,384	28.1	2,331
Active (≥150 min/week)	31.0	2,356	38.6	3,199
Alcohol: frequency				
Infrequent drinkers: Never, monthly, or less frequently	34.6	2,780	33.6	2,701
2-4 times a month	41.0	3,294	35.5	2,852
Regular drinkers: 2-3 times a week; ≥4 times a week	24.3	1,953	30.8	2,478

Note: SD=standard deviation; CFC=childhood financial circumstances. CFC only reported at Tromsø 7 due to recoding of the CFC variable.

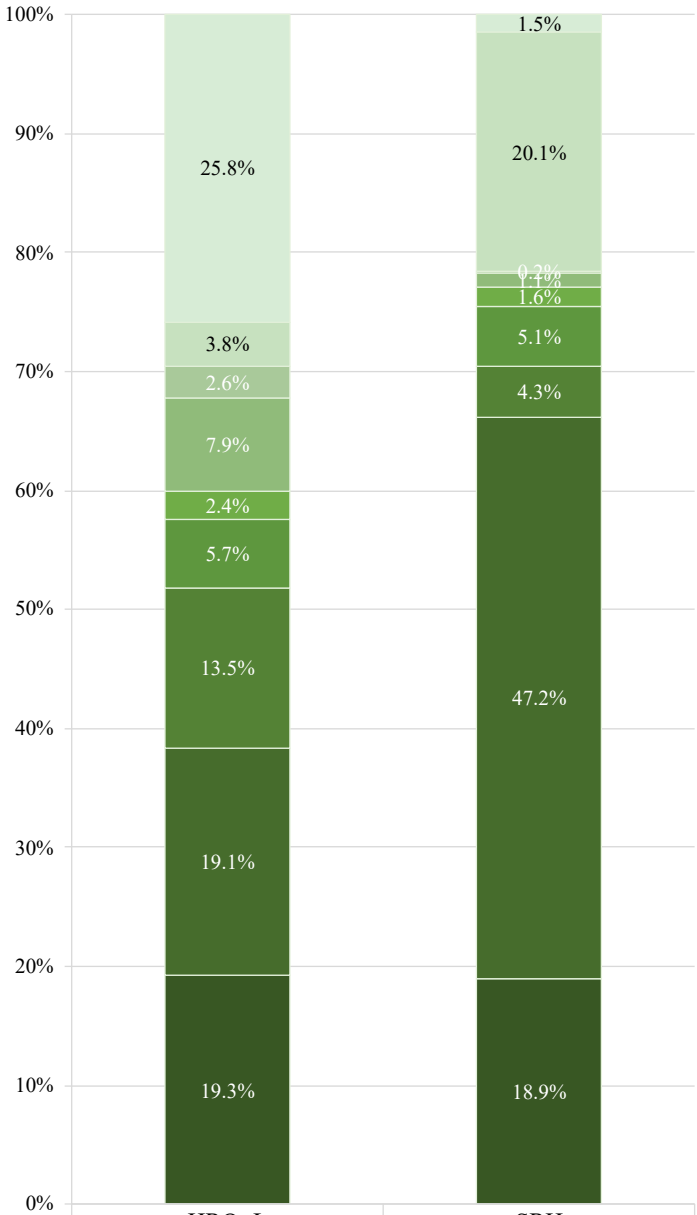
Table 3: *Ex ante* inequality of opportunity (Tromsø 7).

	HRQoL (EQ-5D: Eng)	**SRH**
IOp estimate (SE)	0.034***[a] (0.004)	0.070***[b] (0.008)
Childhood financial circumstances (ref.: good)		
Very difficult/difficult	-0.021*** (0.003)	-0.078*** (0.011)
Very good	0.004 (0.005)	0.019 (0.018)
Own education (ref.: primary education <10 years)		
Upper secondary	0.002 (0.003)	0.069*** (0.014)
Higher education <4 yrs	0.012*** (0.004)	0.161*** (0.015)
Higher education ≥4 yrs	0.022*** (0.003)	0.196*** (0.014)
Height (ref.: 60 % 'normal' height)		
20 % lowest	-0.008** (0.004)	-0.026* (0.014)
20 % tallest	0.002 (0.003)	0.009 (0.015)
Parental somatic health (ref.: 0)		
Mother: 1	-0.007** (0.003)	-0.016 (0.011)
Mother: ≥2	-0.013*** (0.004)	-0.064*** (0.017)
Father: 1	-0.001 (0.003)	-0.015 (0.011)
Father: ≥2	-0.011*** (0.004)	-0.047*** (0.015)
Parental mental health (ref.: 0)	-0.022*** (0.004)	-0.041** (0.018)
Parental substance abuse (ref.: 0)	-0.015*** (0.006)	-0.018 (0.022)
Age groups (ref.: 40-69)		
70-79	0.000 (0.003)	-0.073*** (0.012)
≥80	-0.041*** (0.006)	-0.132*** (0.023)
Sex (ref.: women)	0.024*** (0.003)	-0.000 (0.013)
Constant	0.904*** (0.004)	0.660*** (0.016)
N	8,215	8,215
R^2	0.0527	0.0581

Note: ***p<0.01, **p<0.05, *p<0.1. IOp=Inequality of opportunity; HRQoL=Health-related quality of life; SRH=self-rated health; SE=standard error. IOp estimates' SEs based on bootstrapping (500 replications). Regression models: Robust SEs in parentheses.

[a]IOp measure: variance

[b]IOp measure: dissimilarity index



	HRQoL	SRH
Sex	25.8%	1.5%
Age	3.8%	20.1%
Parental substance abuse	2.6%	0.2%
Parental mental health	7.9%	1.1%
Father's health	2.4%	1.6%
Mother's health	5.7%	5.1%
Height	13.5%	4.3%
Own education	19.1%	47.2%
Childhood financial circumstances	19.3%	18.9%

Figure 1: Shapley decomposition of *Ex ante* inequality of opportunity

Table 4: Direct influence of efforts and indirect influence of circumstances on health (Tromsø 7)

	HRQoL (EQ-5D: Eng)			**SRH**		
	Efforts	**Efforts + circumstances**	**Decomposition of efforts vs circumstances**	**Efforts**	**Efforts + circumstances**	**Decomposition of efforts vs circumstances**
BMI (ref.: BMI <25)						
25-27.49	-0.010*** (0.003)	-0.008*** (0.003)		-0.032** (0.013)	-0.024* (0.013)	
27.5-29.9	-0.016*** (0.003)	-0.013*** (0.003)		-0.067*** (0.014)	-0.056*** (0.015)	
≥30	-0.029*** (0.003)	-0.025*** (0.004)		-0.148*** (0.014)	-0.130*** (0.015)	
Smoking (ref.: Non-smokers)	-0.019*** (0.004)	-0.017*** (0.004)		-0.112*** (0.017)	-0.089*** (0.017)	
Physical activity (ref.: Active)						
Moderate	-0.001 (0.003)	0.001 (0.003)	38.8 %	-0.062*** (0.012)	-0.054*** (0.012)	55.1 %
Inactive	-0.026*** (0.003)	-0.024*** (0.003)		-0.163*** (0.013)	-0.147*** (0.013)	
Alcohol frequency (ref.: Infrequent drinkers)						
2-4 times a month	0.011*** (0.003)	0.010*** (0.003)		0.076*** (0.013)	0.065*** (0.013)	
Regular drinkers (≥2-3 times a week)	0.016*** (0.003)	0.013*** (0.003)		0.111*** (0.013)	0.080*** (0.013)	
Childhood financial circumstances (ref.: good)						
Very difficult/difficult	-	-0.020*** (0.003)		-	-0.071*** (0.011)	
Very good	-	0.005 (0.005)		-	0.024 (0.018)	
Own education (ref.: Primary education <10 years)						
Upper secondary	-	-0.003 (0.003)		-	0.050*** (0.014)	
Higher education <4 yrs	-	0.004 (0.004)		-	0.121*** (0.016)	
Higher education ≥4 yrs	-	0.008** (0.004)		-	0.126*** (0.015)	
Height (ref.: 60 % 'normal' height)						
20 % lowest	-	-0.005 (0.004)	35.1 %	-	-0.006 (0.014)	34.4 %
20 % tallest	-	0.002 (0.003)		-	0.008 (0.014)	
Parental somatic health (ref.: 0)						
Mother: 1	-	-0.005* (0.003)		-	-0.006 (0.011)	
Mother: ≥2	-	-0.010** (0.004)		-	-0.044** (0.017)	
Father: 1	-	-0.000 (0.003)		-	-0.013 (0.011)	
Father: ≥2	-	-0.009** (0.004)		-	-0.037** (0.015)	
Parental mental health (ref.: 0)	-	-0.023*** (0.004)		-	-0.050*** (0.017)	
Parental substance abuse (ref.: 0)	-	-0.014** (0.005)		-	-0.025 (0.021)	

Age groups (ref.: 40-49)			26.1 %			10.5 %
70-79	-0.000 (0.003)	0.001 (0.003)		-0.097*** (0.012)	-0.072*** (0.012)	
≥80	-0.039*** (0.006)	-0.039*** (0.006)		-0.165*** (0.022)	-0.126*** (0.023)	
Sex (ref.: Women)	0.030*** (0.002)	0.027*** (0.003)		0.025** (0.010)	0.015 (0.013)	
Constant	0.908*** (0.003)	0.919*** (0.004)		0.774*** (0.014)	0.744*** (0.020)	
N	8,178	7,984		8,178	7,984	
R^2	0.0614	0.0779		0.0840	0.1014	

Note: ***p<0.01, **p<0.05, *p<0.1. HRQoL=Health-related quality of life; SRH=self-rated health. Robust standard errors in parentheses.

Table 5 a): Fixed-effects panel regression of efforts on health

	HRQoL (EQ-5D: UK/Eng)	**SRH**
BMI (ref.: BMI <25)		
25-27.49	-0.005 (0.005)	-0.029** (0.014)
27.5-29.9	-0.009 (0.007)	-0.060*** (0.020)
≥30	-0.028*** (0.010)	-0.110*** (0.027)
Smoker (ref.: Non-smokers)	0.010 (0.008)	0.034 (0.020)
Physical activity (ref.: Active)		
Moderate	-0.001 (0.004)	-0.018* (0.011)
Inactive	-0.005 (0.005)	-0.039*** (0.013)
Alcohol frequency (ref.: Infrequent drinkers)		
2-4 times a month	0.002 (0.006)	0.015 (0.015)
Regular drinkers (≥2-3 times a week)	-0.008 (0.007)	-0.005 (0.020)
Constant	0.857*** (0.006)	0.748*** (0.017)
F-test	2.36***	4.43***
Number of observations	15,681	15,681
Number of groups/ panel units	8,695	8,695

Note: ***p<0.01, **p<0.05, *p<0.1. HRQoL=Health-related quality of life; SRH=self-rated health. Robust standard errors in parentheses.

Table 5 b): Fixed-effects panel regression of efforts on health, *unfortunate* vs *fortunate*

	HRQoL (UK/Eng)		**SRH**	
	Unfortunate	**Fortunate**	**Unfortunate**	**Fortunate**
BMI (ref.: BMI <25)				
25-27.49	-0.007 (0.010)	-0.011* (0.006)	-0.064* (0.035)	-0.032* (0.017)
27.5-29.9	-0.004 (0.015)	-0.021** (0.009)	-0.075 (0.050)	-0.061** (0.025)
≥30	-0.025 (0.022)	-0.048*** (0.012)	-0.114* (0.064)	-0.119*** (0.033)
Smoker (ref.: Non-smokers)	0.009 (0.022)	0.005 (0.009)	0.058 (0.055)	0.039 (0.025)
Physical activity (ref.: Active)				
Moderate	0.010 (0.010)	-0.004 (0.005)	0.019 (0.025)	-0.021* (0.012)
Inactive	0.006 (0.012)	-0.003 (0.005)	-0.049* (0.028)	-0.034** (0.016)
Alcohol frequency (ref.: Infrequent drinkers)				
2-4 times a month	0.002 (0.014)	0.003 (0.007)	0.007 (0.033)	0.040** (0.019)
Regular drinkers (≥2-3 times /week)	0.009 (0.018)	-0.006 (0.009)	0.026 (0.047)	0.025 (0.024)
Constant	0.814*** (0.015)	0.876*** (0.008)	0.655** (0.042)	0.764*** (0.020)
F-test	0.41	2.97***	1.49	3.58***
Number of observations	*4,213*	*11,279*	*4,213*	*11,279*
Number of groups	*2,860*	*6,741*	*2,860*	*6,741*

Note: ***p<0.01, **p<0.05, *p<0.1. HRQoL=Health-related quality of life; SRH=self-rated health. Robust standard errors in parentheses.

Appendix

Table A1: Matrix reporting the transition probabilities (i.e., proportion transitioning or remaining) between effort categories between Tromsø 6 and 7. Mean raw HRQoL values (measured at Tromsø 7) for the corresponding respondents in parentheses.

a) BMI categories

		Tromsø 7			
Tromsø 6		**<25**	**25.0-27.49**	**27.5-29.9**	**≥30**
	<25	76.9 (0.915)	19.9 (0.910)	3.1 (0.877)	0.2 (0.669)
	25.0-27.49	14.8 (0.915)	53.2 (0.911)	27.7 (0.907)	4.3 (0.861)
	27.5-29.9	2.3 (0.862)	17.8 (0.898)	50.9 (0.908)	29.1 (0.896)
	≥30	0.6 (0.897)	3.3 (0.887)	11.7 (0.880)	84.3 (0.881)

b) Physical activity categories

		Tromsø 7			
Tromsø 6		**Active** (≥150 min/week)	**Moderate** (60-149 min/week)	**Inactive** (<60 min/week)	Total
	Active (≥150 min/week)	65.4 (0.917)	22.2 (0.911)	12.4 (0.858)	100.00
	Moderate (60-149 min/week)	37.4 (0.916)	40.0 (0.917)	22.7 (0.876)	100.00
	Inactive (<60 min/week)	19.7 (0.911)	25.1 (0.910)	55.3 (0.888)	100.00

c) Smoking status

		Tromsø 7		
Tromsø 6		**Non-smoker**	**Smoker**	Total
	Non-smoker	97.8 (0.907)	2.2 (0.895)	100
	Smoker	43.1 (0.888)	56.9 (0.880)	100

d) Alcohol consumption categories

		Tromsø 7			
Tromsø 6		**Infrequent drinkers**	**2-4 times a month**	**Regular drinkers**	Total
	Infrequent drinkers	76.4 (0.884)	21.5 (0.901)	2.1 (0.911)	100.00
	2-4 times a month	15.1 (0.892)	60.4 (0.911)	24.5 (0.915)	100.00
	Regular drinkers	2.7 (0.855)	13.8 (0.891)	83.5 (0.918)	100.00

Table A2 a): *Ex ante* inequality of opportunity by sex. Tromsø 7.

	HRQoL[a] (EQ-5D: Eng)		**SRH**[b]	
	Women	**Men**	**Women**	**Men**
IOp estimate (SE)	0.028*** (0.006)	0.021*** (0.006)	0.076*** (0.011)	0.062*** (0.012)
Childhood financial circumstances (ref.: Good)				
Very difficult/difficult	-0.027*** (0.004)	-0.015*** (0.003)	-0.094*** (0.016)	-0.060*** (0.016)
Very good	0.007 (0.006)	-0.000 (0.007)	-0.000 (0.024)	0.045 (0.028)
Own education (ref.: Primary education <10 years)				
Upper secondary	-0.003 (0.005)	0.005 (0.004)	0.053*** (0.020)	0.086*** (0.021)
Higher education <4 yrs	0.006 (0.005)	0.016*** (0.005)	0.164*** (0.022)	0.160*** (0.022)
Higher education ≥4 yrs	0.019*** (0.005)	0.021*** (0.005)	0.195*** (0.020)	0.199*** (0.022)
Height (ref.: 60 % 'normal' height)				
20 % lowest	-0.008** (0.004)	0.005 (0.014)	-0.021 (0.015)	-0.163* (0.094)
20 % tallest	0.002 (0.021)	0.002 (0.003)	0.040 (0.073)	0.007 (0.015)
Parental somatic health (ref.: 0)				
Mother: 1	-0.007* (0.004)	-0.006 (0.004)	-0.024 (0.016)	-0.005 (0.017)
Mother: ≥2	-0.012** (0.005)	-0.016** (0.007)	-0.052** (0.022)	-0.088*** (0.029)
Father: 1	0.000 (0.004)	-0.003 (0.003)	0.001 (0.015)	-0.035** (0.016)
Father: ≥2	-0.010* (0.005)	-0.012** (0.005)	-0.032 (0.020)	-0.066*** (0.023)
Maternal mental health (ref.: No)	-0.029*** (0.007)	-0.021*** (0.007)	-0.008 (0.026)	-0.038 (0.032)
Paternal mental health (ref.: No)	-0.012 (0.009)	-0.024** (0.011)	-0.064 (0.041)	-0.079 (0.049)
Maternal substance abuse (ref.: No)	0.000 (0.015)	-0.033 (0.022)	-0.046 (0.060)	-0.080 (0.076)
Paternal problems (ref.: No)	-0.011 (0.008)	-0.019** (0.009)	-0.022 (0.032)	-0.012 (0.036)
Age groups (ref.: 40-69)				
70-79	-0.006 (0.004)	0.006* (0.004)	-0.080*** (0.018)	-0.070*** (0.017)
≥80	-0.059*** (0.010)	-0.022*** (0.008)	-0.137*** (0.031)	-0.131*** (0.033)
Constant	0.910*** (0.005)	0.922*** (0.004)	0.662*** (0.020)	0.656*** (0.021)
N	4,392	3,823	4,392	3,823
R^2	0.0474	0.0309	0.0664	0.0520

Note: ***p<0.01, **p<0.05, *p<0.1. IOp=Inequality of opportunity; HRQoL=Health-related quality of life; SRH=Self-rated health; SE=standard error. IOp estimates' SEs based on bootstrapping (500 replications). Regression models: Robust SEs in parentheses.

[a] IOp measure: variance

[b] IOp measure: dissimilarity index

Table A2 b): Shapley decomposition of *Ex ante* inequality of opportunity by sex, Tromsø 7

	HRQoL (EQ-5D: Eng)		**SRH**	
	Women	**Men**	**Women**	**Men**
Shapley decomposition				
Childhood financial circumstances	37.8 %	19.4 %	14.4 %	12.2 %
Own education	23.1 %	31.3 %	48.0 %	48.3 %
Height: age-standardised	5.9 %	0.4 %	6.4 %	3.9 %
Maternal somatic health	3.9 %	11.7 %	5.8 %	5.8 %
Paternal somatic health	2.6 %	5.5 %	0.6 %	4.8 %
Maternal mental health	11.4 %	9.2 %	0.1 %	1.7 %
Paternal mental health	0.3 %	6.1 %	0.7 %	1.6 %
Maternal substance abuse	0.2 %	7.1 %	0.1 %	0.4 %
Paternal problems	0.9 %	9.1 %	0.2 %	0.1 %
Age	14.0 %	0.3 %	23.9 %	21.3 %

Note: HRQoL=Health-related quality of life; SRH=self-reported health.

Table A3: Shapley decomposition of *Ex ante* inequality of opportunity including mother's education. Tromsø 7

	HRQoL[a] (EQ-5D: UK value set)	**SRH**[b]
IOp estimate (SE)	0.034*** (0.004)	0.067*** (0.009)
Shapley decomposition		
Childhood financial circumstances	19.2 %	18.2 %
Own education	18.9 %	44.2 %
Mother's education	1.0 %	6.9 %
Height: age-standardised	13.4 %	3.5 %
Maternal somatic health	5.4 %	4.9 %
Paternal somatic health	2.3 %	1.7 %
Parental mental health	7.9 %	1.1 %
Parental substance abuse	2.6 %	0.2 %
Age	3.8 %	18.1 %
Sex	25.5 %	1.2 %

Note: HRQoL=Health-related quality of life; SRH=self-reported health; SE=standard error, based on bootstrapping (500 replications.

[a] IOp measure: variance

[b] IOp measure: dissimilarity index

Table A4 a) Shapley decomposition of *Ex ante* inequality of opportunity by age groups, Tromsø 7

	HRQoL[a] (EQ-5D: Eng)			**SRH**[b]		
	<55	**55-69**	**≥70**	**<55**	**55-69**	**≥70**
IOp estimate (SE)	0.055*** (0.010)	0.039*** (0.008)	0.051*** (0.009)	0.058*** (0.015)	0.054*** (0.015)	0.073*** (0.015)
Childhood financial circumstances (ref.: Good)						
Very difficult/difficult	-0.020*** (0.005)	-0.019*** (0.004)	-0.026*** (0.005)	-0.074*** (0.023)	-0.067*** (0.018)	-0.091*** (0.020)
Very good	-0.007 (0.009)	0.012* (0.006)	0.010 (0.009)	0.015 (0.029)	0.030 (0.031)	0.014 (0.036)
Own education (ref.: Primary education <10 years)						
Upper secondary	0.020** (0.008)	-0.002 (0.005)	0.000 (0.006)	0.104*** (0.033)	0.069*** (0.023)	0.053** (0.024)
Higher education <4 yrs	0.029*** (0.008)	0.013** (0.005)	0.007 (0.006)	0.218*** (0.033)	0.152*** (0.025)	0.128*** (0.028)
Higher education ≥4 yrs	0.048*** (0.007)	0.019*** (0.005)	0.004 (0.007)	0.244*** (0.032)	0.179*** (0.023)	0.181*** (0.028)
Height (ref.: 60 % 'normal' height)						
20 % lowest	-0.009 (0.007)	-0.001 (0.005)	-0.013* (0.007)	-0.019 (0.025)	-0.051** (0.024)	-0.002 (0.027)
20 % tallest	0.008 (0.006)	0.003 (0.005)	-0.005 (0.006)	-0.007 (0.026)	0.030 (0.023)	-0.002 (0.026)
Parental somatic health (ref.: 0)						
Mother: 1	0.000 (0.005)	-0.012*** (0.004)	-0.007 (0.005)	-0.043** (0.021)	-0.012 (0.018)	0.003 (0.021)
Mother: ≥2	-0.017** (0.008)	-0.010* (0.005)	-0.015* (0.009)	-0.085** (0.034)	-0.045* (0.027)	-0.068** (0.032)
Father: 1	-0.001 (0.005)	0.002 (0.004)	-0.004 (0.005)	-0.031 (0.020)	0.010 (0.018)	-0.029 (0.020)
Father: ≥2	-0.020*** (0.007)	-0.001 (0.005)	-0.012 (0.008)	-0.040 (0.025)	-0.019 (0.024)	-0.100*** (0.031)
Parental mental health (ref.: 0)	-0.022*** (0.007)	-0.028*** (0.007)	-0.012 (0.008)	-0.040 (0.028)	-0.039 (0.027)	-0.051 (0.039)
Parental substance abuse (ref.: 0)	-0.010 (0.009)	-0.023** (0.009)	-0.001 (0.012)	-0.042 (0.034)	-0.019 (0.034)	0.030 (0.053)
Age (years)	0.001 (0.001)	0.002*** (0.000)	-0.004*** (0.001)	0.003 (0.003)	0.002 (0.002)	-0.008*** (0.002)
Sex (ref.: Women)	0.021*** (0.006)	0.016*** (0.004)	0.039*** (0.005)	0.011 (0.023)	-0.026 (0.021)	0.028 (0.024)
Constant	0.842*** (0.040)	0.813*** (0.027)	1.184*** (0.039)	0.500** (0.165)	0.534*** (0.119)	1.182*** (0.153)
N	2,347	3,116	2,752	2,347	3,116	2,752
R^2	0.0644	0.0478	0.0705	0.0554	0.0373	0.0458

Note: ***p<0.01, **p<0.05, *p<0.1. IOp=Inequality of opportunity; HRQoL=Health-related quality of life; SRH=self-rated health; SE=standard error. IOp estimates' SEs based on bootstrapping (500 replications). Regression models: Robust SEs in parentheses.

[a] IOp measure: variance

[b] IOp measure: dissimilarity index

Table A4 b): Shapley decomposition of *Ex ante* inequality of opportunity by age groups (<55; 55-69; and ≥70), Tromsø 7

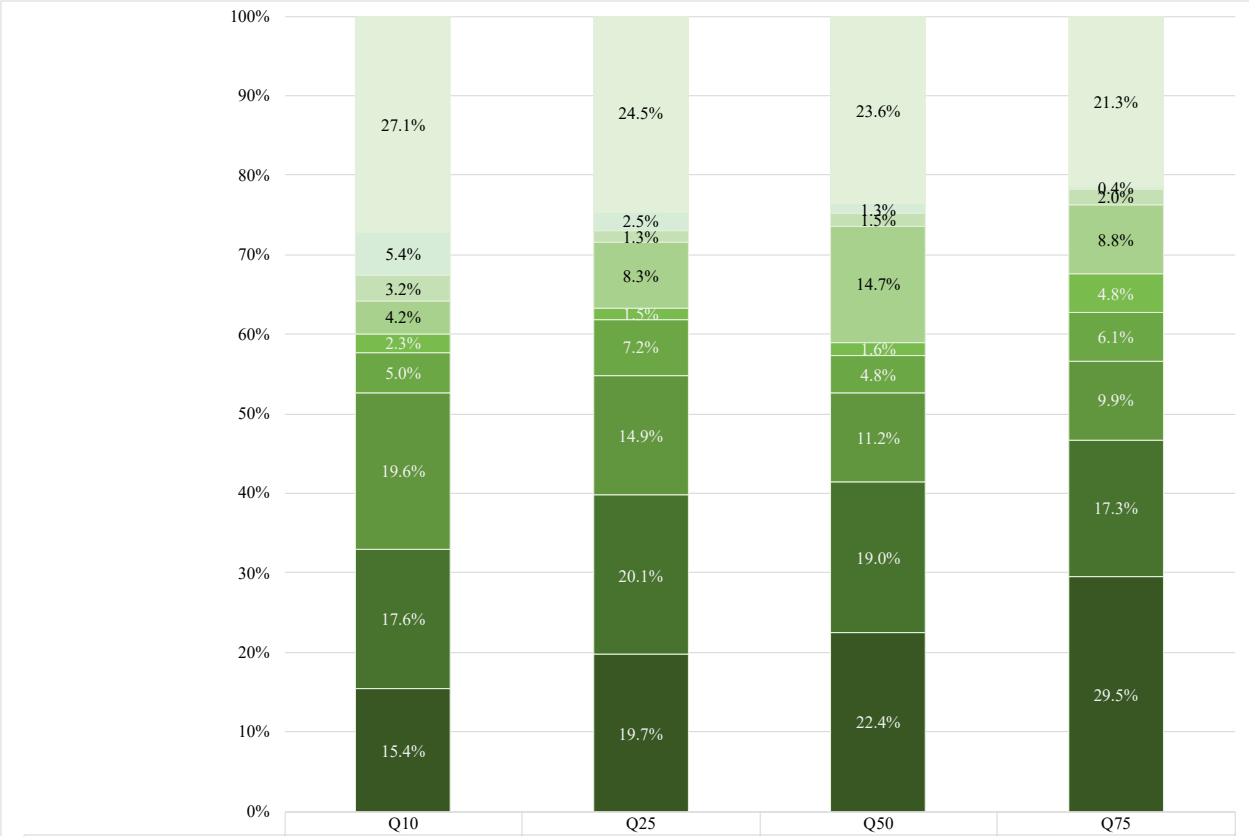
	HRQoL (EQ-5D: Eng)			**SRH**		
	<55	**55-69**	**≥70**	**<55**	**55-69**	**≥70**
Shapley decomposition						
Childhood financial circumstances	11.5 %	21.0 %	14.7 %	14.3 %	21.5 %	22.4 %
Own education	32.5 %	14.1 %	5.2 %	59.4 %	55.4 %	37.1 %
Height: age-standardised	12.5 %	5.4 %	13.3 %	3.6 %	10.0 %	4.0 %
Maternal somatic health	4.2 %	9.1 %	5.4 %	11.9 %	5.1 %	5.3 %
Paternal somatic health	12.7 %	0.1 %	0.9 %	5.0 %	2.2 %	7.6 %
Parental mental health	9.0 %	20.1 %	0.3 %	3.2 %	2.8 %	1.3 %
Parental substance abuse	2.1 %	10.1 %	0.0 %	2.0 %	0.7 %	0.9 %
Age (years)	0.5 %	10.1 %	28.8 %	0.3 %	0.6 %	15.2 %
Sex	15.1 %	9.9 %	31.4 %	0.2 %	1.7 %	6.2 %

Note: HRQoL=Health-related quality of life; SRH=self-reported health.

Table A5: Recentred influence factor: HRQoL (EQ-5D: Eng) regressed on circumstances.

	10th quantile	**25th quantile**	**50th quantile**	**75th quantile**
IOp estimate (SE)	0.020*** (0.000)	0.035*** (0.004)	0.042*** (0.004)	0.035*** (0.004)
Childhood financial circumstances (ref.: Good)				
Very difficult/difficult	-0.039*** (0.009)	-0.020*** (0.003)	-0.011*** (0.001)	-0.011*** (0.001)
Very good	0.002 (0.013)	0.004 (0.005)	0.004* (0.002)	0.008*** (0.003)
Own education (ref.: Primary education <10 years)				
Upper secondary	0.009 (0.011)	0.002 (0.004)	0.003** (0.002)	-0.001 (0.002)
Higher education <4 yrs	0.031*** (0.012)	0.012*** (0.004)	0.008*** (0.002)	0.004** (0.002)
Higher education ≥4 yrs	0.043*** (0.011)	0.023*** (0.004)	0.012*** (0.002)	0.011*** (0.002)
Height (ref.: 60 % 'normal' height)				
20 % lowest	-0.032** (0.012)	-0.010** (0.004)	-0.001 (0.002)	-0.001 (0.002)
20 % tallest	-0.001 (0.010)	0.004 (0.004)	0.003 (0.002)	0.002 (0.002)
Parental somatic health (ref.: 0)				
Mother: 1	-0.017** (0.009)	-0.008*** (0.003)	-0.001 (0.001)	-0.003* (0.001)
Mother: ≥2	-0.025* (0.014)	-0.017*** (0.004)	-0.007*** (0.002)	-0.007*** (0.002)
Father: 1	-0.003 (0.008)	0.001 (0.003)	0.000 (0.001)	-0.003* (0.001)
Father: ≥2	-0.022* (0.012)	-0.007* (0.004)	-0.004** (0.002)	-0.007*** (0.002)
Parental mental health (ref.: 0)	-0.032** (0.014)	-0.023*** (0.005)	-0.015*** (0.002)	-0.010*** (0.002)
Parental substance abuse (ref.: 0)	-0.037** (0.018)	-0.011* (0.006)	-0.005* (0.003)	-0.006** (0.003)
Age groups (ref.: 40-69)				
70-79	0.002 (0.009)	0.000 (0.003)	0.002 (0.001)	0.003** (0.002)
≥80	-0.107*** (0.020)	-0.044*** (0.007)	-0.018*** (0.003)	-0.007*** (0.003)
Sex (ref.: Women)	0.049*** (0.009)	0.023*** (0.003)	0.012*** (0.002)	0.011*** (0.002)
Constant	0.786*** (0.012)	0.874*** (0.004)	0.944*** (0.002)	1.004*** (0.002)
N	*8,215*	*8,215*	*8,215*	*8,215*
R^2	*0.0248*	*0.0422*	*0.0478*	*0.0362*

Note: ***p<0.01, **p<0.05, *p<0.1. IOp=Inequality of opportunity; HRQoL=Health-related quality of life; SE=standard error. Robust SEs in parentheses. IOp estimate SEs are derived from bootstrapping with 500 replications.



	Q10	Q25	Q50	Q75
Sex	27.1%	24.5%	23.6%	21.3%
Age	5.4%	2.5%	1.3%	0.4%
Parental substance abuse	3.2%	1.3%	1.5%	2.0%
Parental mental health	4.2%	8.3%	14.7%	8.8%
Father's health	2.3%	1.5%	1.6%	4.8%
Mother's health	5.0%	7.2%	4.8%	6.1%
Height	19.6%	14.9%	11.2%	9.9%
Own education	17.6%	20.1%	19.0%	17.3%
Childhood financial circumstances	15.4%	19.7%	22.4%	29.5%

Figure A1: Shapley value decomposition of the sources of inequality in health-related quality of life due to circumstances for the 10th, 25th, 50th, and 75th quantiles (Q10-Q75).

Table A6: Circumstance variables as predictors of separate effort variables

	BMI	Smoking	Physical activity	Alcohol consumption
Childhood financial circumstances (ref.: Good)				
Very difficult/difficult	0.158 (0.105)	-0.039 (0.041)	0.043 (0.028)	-0.097*** (0.028)
Very good	0.344* (0.190)	-0.068 (0.072)	-0.041 (0.048)	-0.087* (0.048)
Own education (ref.: Primary education <10 years)				
Upper secondary	-0.274** (0.129)	-0.155*** (0.046)	-0.148*** (0.034)	0.302*** (0.033)
Higher education <4 yrs	-0.622*** (0.144)	-0.407*** (0.056)	-0.298*** (0.039)	0.490*** (0.038)
Higher education ≥4 yrs	-1.494*** (0.137)	-0.753*** (0.059)	-0.467*** (0.037)	0.763*** (0.037)
Height (ref.: 60 % 'normal' height)				
20 % lowest	0.594*** (0.147)	0.036 (0.051)	0.090** (0.036)	-0.220*** (0.036)
20 % tallest	-0.250** (0.123)	0.008 (0.055)	0.079** (0.037)	0.057 (0.036)
Parental somatic health (ref.: 0)				
Mother: 1	0.433*** (0.108)	-0.013 (0.041)	0.048* (0.028)	0.002 (0.028)
Mother: ≥2	0.709*** (0.161)	-0.036 (0.061)	0.038 (0.042)	-0.080* (0.042)
Father: 1	0.344*** (0.104)	-0.002 (0.041)	0.031 (0.028)	0.016 (0.028)
Father: ≥2	0.753*** (0.147)	-0.004 (0.054)	0.065* (0.037)	-0.003 (0.037)
Parental mental health (ref.: 0)	-0.533*** (0.155)	0.015 (0.063)	0.011 (0.043)	-0.014 (0.043)
Parental substance abuse (ref.: 0)	0.070 (0.205)	0.094 (0.077)	-0.043 (0.055)	0.131** (0.054)
Age groups (ref.: 40-69)				
70-79	0.001 (0.112)	-0.382*** (0.046)	-0.029 (0.030)	-0.106*** (0.030)
≥80	-0.928*** (0.183)	-0.644*** (0.092)	0.001 (0.054)	-0.480*** (0.055)
Sex (ref.: Women)	1.054*** (0.121)	-0.090* (0.048)	0.159*** (0.033)	0.122*** (0.032)
Constant	26.881*** (0.146)	0.744*** (0.053)	-0.352 (0.039)	-0.178 (0.038)
			0.392 (0.039)	0.815 (0.039)
N	*8,214*	*8,142*	*8,064*	*8,188*
(Pseudo) R^2	*0.0384*	*0.0467*	*0.0145*	*0.0490*

Note: ***p<0.01, **p<0.05, *p<0.1. Robust standard errors in parentheses. BMI is modelled as a continuous variable and is therefore analysed using ordinary least squares regression. Smoking is analysed using probit regression. The physical activity and alcohol consumption models are analysed using ordered probit regression, with 'Active' and 'Infrequent drinkers' as the reference categories, respectively.

Table A7: Maintenance/change in efforts between Tromsø 6 and 7 and their influence on HRQoL and SRH in Tromsø 7

	HRQoL (EQ-5D: Eng)	**SRH**
BMI change/maintenance (ref.: Maintain normal weight)		
Overweight to obese	-0.029*** (0.006)	-0.143*** (0.023)
Normal to obese	-0.255 (0.120)	-0.443*** (0.117)
Normal to overweight	-0.008* (0.004)	-0.033* (0.020)
Obese to overweight	-0.030*** (0.009)	-0.107*** (0.033)
Obese to normal	0.025 (0.036)	-0.087 (0.148)
Overweight to normal	-0.011* (0.007)	-0.016 (0.025)
Maintain obese	-0.014*** (0.005)	-0.027 (0.019)
Maintain overweight	-0.011*** (0.004)	-0.038** (0.017)
Smoking change/maintenance (ref.: Remaining smoke-free)		
Initiate smoking	-0.012 (0.011)	-0.111** (0.036)
Quit smoking	-0.014** (0.006)	-0.082*** (0.025)
Keep on smoking	-0.025*** (0.006)	-0.114*** (0.022)
Physical activity change/maintenance (ref.: Maintaining active)		
Active to inactive	-0.046*** (0.010)	-0.182*** (0.036)
Moderate to inactive	-0.032*** (0.007)	0.162*** (0.028)
Active to moderate	-0.003 (0.006)	-0.046* (0.025)
Inactive to moderate	-0.005 (0.005)	-0.099*** (0.023)
Moderate to active	-0.002 (0.004)	-0.003 (0.019)
Inactive to active	0.003 (0.005)	-0.020 (0.024)
Maintaining inactive	-0.021*** (0.005)	-0.177*** (0.019)
Maintaining moderate activity	0.000 (0.004)	-0.046** (0.019)
Alcohol consumption change/maintenance (ref.: Maintaining infrequent drinking)		
Infrequent to regular	0.028* (0.015)	0.153** (0.072)
2-4 times /month to regular	0.011** (0.005)	0.116*** (0.022)
Infrequent to 2-4 times /month	0.006 (0.006)	0.050* (0.026)
Regular to 2-4 times /month	0.005 (0.008)	0.077** (0.034)
2-4 times a month to infrequent	0.002 (0.008)	0.057** (0.029)
Regular to infrequent	-0.040 (0.024)	-0.043 (0.078)
Maintaining regular drinking	0.014*** (0.004)	0.132*** (0.018)

Maintaining drinking 2-4 times /month	0.012*** (0.004)	0.110*** (0.018)
Age groups (ref.: 40-69)		
70-79	0.001 (0.003)	-0.110*** (0.014)
≥80	-0.032*** (0.007)	-0.165*** (0.027)
Sex (ref.: Women)	0.025*** (0.003)	0.015 (0.012)
Constant	0.914*** (0.004)	0.781*** (0.019)
N	*5,620*	*5,620*
R^2	*0.0659*	*0.0907*

Note: ***p<0.01, **p<0.05, *p<0.1. HRQoL=Health-related quality of life; SRH=self-reported health. Robust standard errors in parentheses. Based on dummies in which the unchanged category corresponds to those who have the same level of effort over the two waves; the worsening refers to those who worsen their effort (e.g., start smoking or increase the BMI category) between Tromsø 6 and 7; and improvement refers to those who improve their effort (e.g., increase their physical activity level) from Tromsø 6 to 7.

Table A8: Oaxaca decomposition/counterfactual analysis. Tromsø 7.

	HRQoL	**SRH**
Mean prediction: unfortunate	0.886	0.596
Mean prediction: fortunate	0.911	0.697
Difference	0.025	0.101
Explained	0.001 (0.001)	0.022*** (0.004)
Proportion explained (explained/difference)	3.0 %	21.8 %
Unexplained	0.024*** (0.003)	0.078*** (0.012)
Proportion unexplained (unexplained/difference)	95.0 %	76.8 %
N	8,113	8,113

Note: ***p<0.01, **p<0.05, *p<0.1. HRQoL=Health-related quality of life; SRH=self-rated health.

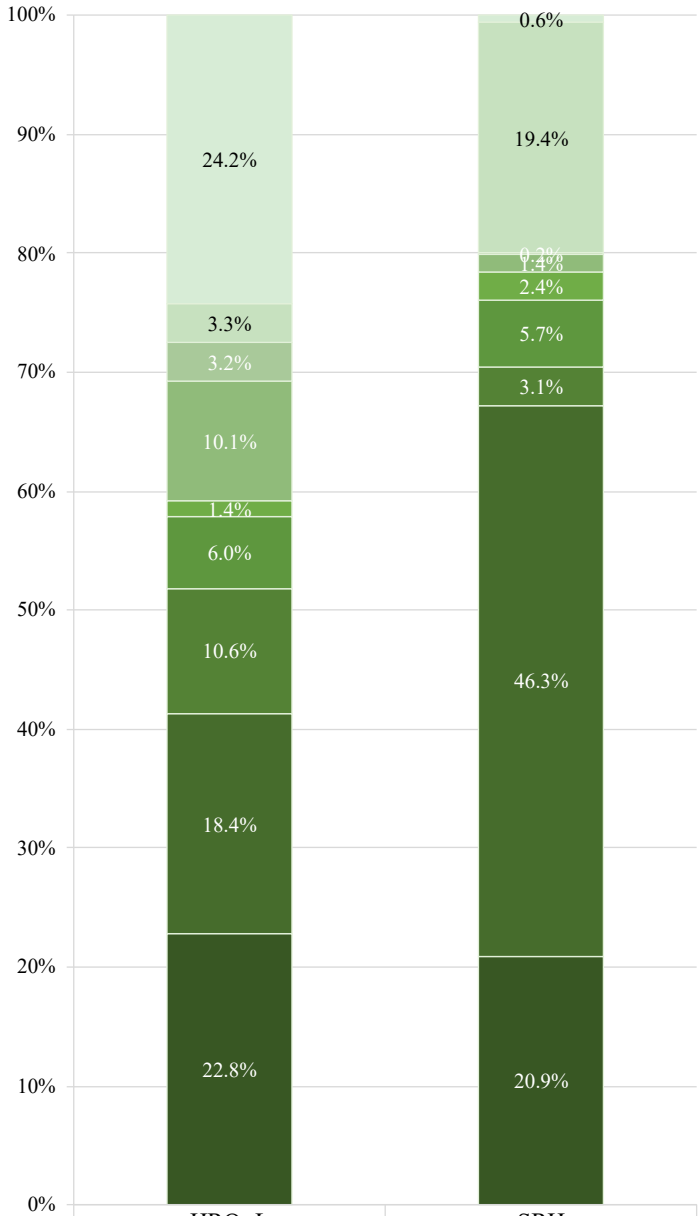
Table A9: *Ex ante* inequality of opportunity (Tromsø 7), panel sample.

	HRQoL (EQ-5D: Eng)	**SRH**
IOp estimate (SE)	0.034*** [a] (0.004)	0.068*** [b] (0.009)
Childhood financial circumstances (ref.: Good)		
Very difficult/difficult	-0.022*** (0.003)	-0.084*** (0.012)
Very good	0.005 (0.005)	0.014 (0.019)
Own education (ref.: Primary education <10 years)		
Upper secondary	0.002 (0.003)	0.067*** (0.015)
Higher education <4 yrs	0.012*** (0.004)	0.155*** (0.016)
Higher education ≥4 yrs	0.022*** (0.003)	0.192*** (0.015)
Height (ref.: 60 % 'normal' height)		
20 % lowest	-0.006 (0.004)	-0.019 (0.015)
20 % tallest	0.001 (0.003)	0.005 (0.015)
Parental somatic health (ref.: 0)		
Mother: 1	-0.007** (0.003)	-0.019 (0.012)
Mother: ≥2	-0.014*** (0.004)	-0.062*** (0.018)
Father: 1	-0.001 (0.003)	-0.016 (0.012)
Father: ≥2	-0.008** (0.004)	-0.053*** (0.016)
Parental mental health (ref.: 0)	-0.024*** (0.004)	-0.044** (0.018)
Parental substance abuse (ref.: 0)	-0.014*** (0.006)	-0.024 (0.023)
Age groups (ref.: 40-69)		
70-79	0.001 (0.003)	-0.069*** (0.013)
≥80	-0.039*** (0.006)	-0.126*** (0.024)
Sex (ref.: Women)	0.024*** (0.003)	-0.005 (0.014)
Constant	0.905*** (0.004)	0.674*** (0.016)
N	7,516	7,516
R^2	0.0525	0.0567

Note: ***p<0.01, **p<0.05, *p<0.1. IOp=Inequality of opportunity; HRQoL=Health-related quality of life; SRH=self-rated health; SE=standard error. IOp estimates' SEs based on bootstrapping (500 replications). Regression models: Robust SEs in parentheses.

[a] IOp measure: variance

[b] IOp measure: dissimilarity index



	HRQoL	SRH
Sex	24.2%	0.6%
Age	3.3%	19.4%
Parental substance abuse	3.2%	0.2%
Parental mental health	10.1%	1.4%
Father's health	1.4%	2.4%
Mother's health	6.0%	5.7%
Height	10.6%	3.1%
Own education	18.4%	46.3%
Childhood financial circumstances	22.8%	20.9%

Figure A2: Shapley value decomposition of the sources of inequality due to circumstances. Panel sample.

Table A10: Direct influence of efforts on health and indirect influences of circumstances on health, panel sample.

	HRQoL (EQ-5D: Eng)			**SRH**		
	Efforts	**Efforts + circumstances**	**Decomposition of efforts vs circumstances**	**Efforts**	**Efforts + circumstances**	**Decomposition of efforts vs circumstances**
BMI (ref.: BMI <25)						
25-27.49	-0.009*** (0.003)	-0.007*** (0.003)		-0.028** (0.013)	-0.021* (0.013)	
27.5-29.9	-0.014*** (0.003)	-0.012*** (0.003)		-0.066*** (0.015)	-0.055*** (0.015)	
≥30	-0.027*** (0.004)	-0.023*** (0.004)		-0.147*** (0.015)	-0.130*** (0.015)	
Smoking (ref.: Non-smokers)	-0.017*** (0.004)	-0.015*** (0.004)		-0.109*** (0.018)	-0.087*** (0.018)	
Physical activity (ref.: Active)						
Moderate	-0.003 (0.003)	-0.001 (0.003)	37.3 %	-0.064*** (0.012)	-0.055*** (0.012)	55.7 %
Inactive	-0.027*** (0.003)	-0.025*** (0.003)		-0.164*** (0.013)	-0.151*** (0.013)	
Alcohol frequency (ref.: Infrequent drinkers)						
2-4 times a month	0.010*** (0.003)	0.009*** (0.003)		0.070*** (0.013)	0.060*** (0.013)	
Regular drinkers (≥2-3 times a week)	0.015*** (0.003)	0.012*** (0.003)		0.108*** (0.013)	0.078*** (0.014)	
Childhood financial circumstances (ref.: Good)						
Very difficult/difficult	-	-0.021*** (0.003)		-	-0.077*** (0.012)	
Very good	-	0.006 (0.005)		-	0.019 (0.019)	
Own education (ref.: Primary education <10 years)						
Upper secondary	-	-0.003 (0.004)		-	0.047*** (0.015)	
Higher education <4 yrs	-	0.004 (0.004)		-	0.115*** (0.016)	
Higher education ≥4 yrs	-	0.008** (0.004)		-	0.121*** (0.016)	
Height (ref.: 60 % 'normal' height)						
20 % lowest	-	-0.003 (0.004)	37.4 %	-	-0.000 (0.015)	34.8 %
20 % tallest	-	0.002 (0.003)		-	0.006 (0.015)	
Parental somatic health (ref.: 0)						
Mother: 1	-	-0.005** (0.003)		-	-0.012 (0.012)	
Mother: ≥2	-	-0.010** (0.004)		-	-0.046** (0.018)	
Father: 1	-	-0.001 (0.003)		-	-0.015 (0.011)	
Father: ≥2	-	-0.007* (0.004)		-	-0.043*** (0.015)	
Parental mental health (ref.: 0)	-	-0.025*** (0.004)		-	-0.053*** (0.018)	
Parental substance abuse (ref.: 0)	-	-0.013** (0.006)		-	-0.028 (0.022)	

Age groups (ref.: 40-49)			25.4 %			9.5 %
70-79	-0.000 (0.003)	0.001 (0.003)		-0.091*** (0.012)	-0.069*** (0.013)	
≥80	-0.038*** (0.006)	-0.037*** (0.006)		-0.154*** (0.023)	-0.118*** (0.025)	
Sex (ref.: Women)	0.029*** (0.003)	0.027*** (0.003)		0.016** (0.011)	0.011 (0.014)	
Constant	0.909*** (0.003)	0.920*** (0.005)		0.783*** (0.014)	0.760*** (0.020)	
N	7,481	7,331		7,481	7,331	
R^2	0.0573	0.0762		0.0807	0.1002	

Note: ***p<0.01, **p<0.05, *p<0.1. Robust standard errors in parentheses.

Appendices

A. Table of summary statistics of the included variables in Papers I and III, full Tromsø 7 sample

B. Ethical approval for the PhD project from the Regional Committees for Medical and Health Research Ethics [Norwegian]

C. The first questionnaire (Q1) from Tromsø 6 and extracted pages from the second questionnaire (Q2) from Tromsø 6

D. The first questionnaire (Q1) from Tromsø 7 and extracted pages from the second questionnaire (Q2) from Tromsø 7

E. List of links related to the Tromsø study: Tromsø 6 and 7

F. Questionnaire SEP Survey (Section C), including information about the study and consent form, Australia

G. Questionnaire SEP Survey (Section C), including information about the study and consent form, Norway [Norwegian]

Appendix A

Table of summary statistics of the included variables in Papers I and III, full Tromsø 7 sample

	Female		Male		Total	
Variables	**Mean/%**	**N**	**Mean/%**	**N**	**Mean/%**	**N**
Health						
EQ-5D: WePP (SD)	0.88 (0.11)	10,638	0.90 (0.10)	9,628	0.89 (0.11)	20,266
EQ-5D: English value set (SD)	0.89 (0.12)	10,638	0.91 (0.11)	9,628	0.90 (0.11)	20,266
VAS (SD)	0.76 (0.17)	10,830	0.76 (0.16)	9,824	0.76 (0.16)	20,654
Self-rated health						
Very bad/bad	6.24	683	4.81	478	5.56	1,161
Neither good nor bad	25.91	2,837	26.25	2,609	26.07	5,446
Good	51.5	5,639	56.19	5,585	53.73	11,224
Excellent	16.35	1,790	12.76	1,268	14.64	3,058
Demographic characteristics						
Sex	52.51	11,063	47.49	10,006	100.00	21,069
Age						
Years (SD)	57.23 (11.45)	11,063	57.42 (11.39)	10,006	100.00	21,069
40-49	30.49	3,373	30.51	3,053	30.50	6,426
50-59	29.32	3,244	27.86	2,788	28.63	6,032
60-69	24.17	2,674	25.00	2,502	24.57	5,176
70-79	12.29	1,360	13.14	1,315	12.70	2,675
≥80	3.72	412	3.48	348	3.61	760
Socioeconomic and circumstance variables						
Subjective SEP						
Low status	7.49	800	6.07	592	6.81	1,392
Middle	54.84	5,854	47.04	4,588	51.12	10,442
Fairly high	31.62	3,375	38.80	3,784	35.05	7,159
Very high	6.05	646	8.09	789	7.02	1,435
Education level						
Primary education	24.08	2,616	22.17	2,179	23.17	4,795
Upper secondary	25.34	2,753	30.47	2,995	27.78	5,748
Undergraduate	17.63	1,915	21.27	2,090	19.36	4,005
Post-graduate	32.95	3,579	26.09	2,564	29.69	6,143
Household income						
Low	26.87	2,796	17.87	1,745	22.51	4,541
Lower middle	29.64	3,084	28.62	2,795	29.15	5,879
Upper middle	21.80	2,268	25.27	2,468	23.48	4,736
High	21.69	2,257	28.24	2,758	24.86	5,015
Childhood financial circumstances						
(Very) difficult	26.89	2,934	28.85	2,850	27.82	5,784
Good	65.82	7,183	64.7	6,390	65.29	13,573
Very good	7.29	796	6.45	637	6.89	1,433
Mother's education						
Primary education	73.57	7,858	72.94	7,073	73.27	14,931
Upper secondary	16.16	1,726	17.23	1,671	16.67	3,397
Higher education	10.27	1,097	9.83	953	10.06	2,050
Height in cm (SD)	164.27 (6.52)	11,029	177.72 (6.78)	9,980	170.6 (9.45)	21,009
Maternal somatic health (no. of diagnoses/conditions)						
0	57.81	6,333	64.46	6,376	60.97	12,709
1	30.06	3,293	27.94	2,764	29.06	6,057
≥2	12.13	1,329	7.59	751	9.98	2,080

Paternal somatic health (no. of diagnoses/conditions)						
0	49.11	5,382	53.04	5,248	50.98	10,630
1	34.26	3,754	32.30	3,196	33.33	6,950
≥2	16.63	1,822	14.66	1,451	15.70	3,273
Parental mental health: No	87.17	9,540	90.63	8,960	88.81	18,500
Yes	12.83	1,404	9.37	926	11.19	2,330
Parental substance abuse: No	92.73	10,148	93.09	9,203	92.90	19,351
Yes	7.27	796	6.91	683	7.10	1,479
Lifestyle variables						
BMI category						
<25	40.24	4,434	24.17	2,410	32.60	6,844
25.0-27.49	21.08	2,323	27.46	2,739	24.12	5,062
27.5-29.9	16.06	1,769	23.26	2,320	19.48	4,089
≥30	22.62	2,492	25.11	2,504	23.80	4,996
Smoking						
No/previously	85.62	9,274	87.12	8,535	86.33	17,809
Yes	14.38	1,557	12.88	1,262	13.67	2,819
Physical activity						
Inactive	30.01	3,220	37.28	3,631	33.47	6,851
Moderate	31.03	3,330	27.06	2,636	29.15	5,966
Active	38.96	4,180	35.66	3,473	37.39	7,653
Alcohol: frequency						
Infrequent	37.80	4,151	26.88	2,676	32.61	6,827
2-4 times a month	35.96	3,949	39.60	3,943	37.69	7,892
Regular drinkers	26.24	2,882	33.52	3,337	29.70	6,219

Note: WePP=Western Preference Pattern; SD=Standard deviation; VAS=Visual analogue scale; BMI=Body mass index.

Appendix B

Ethical approval for the PhD project from the Regional Committees for Medical and Health Research Ethics [Norwegian]

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK nord			25.04.2019	2019/607/REK nord
			Deres dato:	Deres referanse:
			19.03.2019	

Vår referanse må oppgis ved alle henvendelser

Jan Abel Olsen
ISM

2019/607 Helsesjokk og resiliens

Forskningsansvarlig institusjon: UiT Norges arktiske universitet
Prosjektleder: Jan Abel Olsen

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK nord) i møtet 11.04.2019. Vurderingen er gjort med hjemmel i helseforskningsloven (hforsknl) § 10.

Prosjektleders prosjektomtale
Formålet med dette prosjektet er utforske folks robusthet, motstandskraft og evne til å mobilisere for å bevare helsa når de utsettes for riskofaktorer som er assosiert med redusert helse. Studien har et livsløpsperspektiv og er basert på data fra Tromsøundersøkelsen som kobles med registerdata om sykdomsforløp, arbeidslivsdeltakelse og sosio-økonomisk posisjon. Vi ønsker spesifikt å undersøke hvordan godt voksne personer, dvs. de som opplever helse-sjokk i form av kardiovaskulære hendelser, kreftdiagnoser og psykisk sykdom etter fylte 50 år håndterer dem. Våre analyser vil ha sitt utgangspunkt i personer som har deltatt i Tromsø 7 som ble gjennomført i 2015-16 (N= 21 083), Tromsø 6 som ble gjennomført i 2007-08 (N = 12 981) og Tromsø 4 som ble gjennomført i 1994-95 (N = 27 158). Det er 7 288 personer som har deltatt i alle disse tre undersøkelsene. Prosjektet vil gi ny kunnskap som vil være nyttig for å møte utfordringer i helse- og velferdssektoren framover.

Om prosjektet
Det fremgår av protokollen at formålet med prosjektet er å *«undersøke hvordan godt voksne personer, dvs. de som opplever helse-sjokk etter fylte 50 år håndterer dem»*. Mer spesifikt vil man undersøke tre typer helse-sjokk: kardiovaskulære hendelser, kreftdiagnoser og psykisk sykdom.

Søker skriver at: *«Et viktig utgangspunkt for dette prosjektet er at analysene vil baseres på livsløpdata som krever et omfattende sett med variabler. Forskningsspørsmålene vil søkes belyst med utgangspunkt i data fra Tromsøundersøkelsen. Men for å dekke de aspektene vi er interessert i, er vi avhengig av kobling på individnivå til data fra Norsk pasientregister (NPR) og FD Trygd samt data om inntekt og yrke fra SSB.»*

For å dekke de beskrevne aspektene i prosjektet er man avhengig av opplysninger om voksne personers barndomsforhold, sosioøkonomiske posisjon, helserelaterte atferd, sosiale relasjoner, helse, opplevde helse-sjokk og arbeidsmarkedstilknytning. Mesteparten av denne informasjonen finnes i Tromsøundersøkelsen, men det søkes om mer detaljert informasjon om opplevde helse-sjokk fra Norsk pasientregister, om arbeidsmarkedstilknytning fra FD Trygd og om inntekt og yrke fra SSB sine registre.

Vurdering av om samtykkene er dekkende
Det er innhentet samtykke for deltakere i Tromsø 4, 5, 6 og 7. Felles for disse er at de har mottatt informasjon om studien, samtykket til at innsamlede data kan brukes til medisinsk forskning, samt sammenstilling mot ulike registre.

REK anser at samtykket er dekkende for de omsøkte sammenstillinger og har ingen innvendinger mot de omsøkte sammenstillinger. Vi gjør prosjektleder oppmerksom på at FD Trygd og SSB selv råder over data i sine registre og gjør selvstendige vurderinger av tilgjengeliggjøring av data og sammenstilling.

Vedtak
REK har gjort en helhetlig forskningsetisk vurdering av alle prosjektets sider og godkjenner det med hjemmel i helseforskningsloven § 10.
Vi gjør samtidig oppmerksom på at etter ny personopplysningslov må det også foreligge et behandlingsgrunnlag etter personvernforordningen. Dette må forankres i egen institusjon. (UiT bruker NSD for å ivareta sine plikter på dette området.)

Sluttmelding og søknad om prosjektendring
Prosjektleder skal sende sluttmelding til REK nord på eget skjema senest 28.02.2025, jf. hfl. § 12. Prosjektleder skal sende søknad om prosjektendring til REK nord dersom det skal gjøres vesentlige endringer i forhold til de opplysninger som er gitt i søknaden, jf. hfl. § 11.

Klageadgang
Du kan klage på komiteens vedtak, jf. forvaltningsloven § 28 flg. Klagen sendes til REK nord. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK nord, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Med vennlig hilsen

May Britt Rossvoll
sekretariatsleder

Kopi til:ashild.tempel@uit.no;postmottak@uit.no

Appendix C

The first questionnaire (Q1) from Tromsø 6 and extracted pages from the second questionnaire (Q2) from Tromsø 6

Tromsø-undersøkelsen

The form will be read electronically. Please use a blue or black pen
You can not use comas, use upper-case letters.

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HEALTH AND DISEASES

1 **How do you in general consider your own health to be?**

- ☐ Very good
- ☐ Good
- ☐ Neither good nor bad
- ☐ Bad
- ☐ Very bad

2 **How is your health compared to others in your age?**

- ☐ Much better
- ☐ A little better
- ☐ About the same
- ☐ A little worse
- ☐ Much worse

3 **Do you have, or have you had?**

	Yes	No	Age first time
Heart attack	☐	☐	
Angina pectoris	☐	☐	
Stroke/brain hemorrhage	☐	☐	
Atrial fibrillation	☐	☐	
High blood pressure	☐	☐	
Osteoporosis	☐	☐	
Asthma	☐	☐	
Chronic bronchitis/Emphysyma/COPD	☐	☐	
Diabetes mellitus	☐	☐	
Psychological problems *(for which you have sought help)*	☐	☐	
Low metabolism	☐	☐	
Kidney disease, *not including urinary tract infection (UTI)*	☐	☐	
Migraine	☐	☐	

4 **Do you have persistent or constantly recurring pain that has lasted for 3 months or more?**

☐ Yes ☐ No

5 **How often have you suffered from sleeplessness during the last 12 months?**

- ☐ Never, or just a few times
- ☐ 1-3 times a month
- ☐ Approximately once a week
- ☐ More that once a week

6 **Below you find a list of different situations. Have you experienced some of them in the last week (including today)?** (Tick once for each complaint)

	No complaint	Little complaint	Pretty much	Very much
Sudden fear without reason	☐	☐	☐	☐
You felt afraid or worried	☐	☐	☐	☐
Faintness or dizziness	☐	☐	☐	☐
You felt tense or upset	☐	☐	☐	☐
Easily blamed yourself	☐	☐	☐	☐
Sleeping problems	☐	☐	☐	☐
Depressed, sad	☐	☐	☐	☐
You felt useless, worthless	☐	☐	☐	☐
Feeling that life is a struggle	☐	☐	☐	☐
Feeling of hopelessness with regard to the future	☐	☐	☐	☐

USE OF HEALTH SERVICES

7 **Have you during the past year visited:**
If YES; how many times?

	Yes	No	No. of times
General practitioner (GP)	☐	☐	
Psychiatrist/psychologist	☐	☐	
Medical specialist outside hospital *(other than general practitioner/psychiatrist)*	☐	☐	
Physiotherapist	☐	☐	
Chiropractor	☐	☐	
Alternative medical practitioner *(homeopath, acupuncturist, foot zone therapist, herbal medical practitioner, laying on hands practitioner, healer, clairvoyant, etc.)*	☐	☐	
Dentist/dental service	☐	☐	

8 **Have you during the last 12 months been to a hospital?**

	Yes	No	No. of times
Admitted to a hospital	☐	☐	
Had consultation in a hospital without admission;			
At psychiatric out-patient clinic	☐	☐	
At another out-patient clinic	☐	☐	

9 **Have you undergone any surgery during the last 3 years?**

☐ Yes ☐ No

USE OF MEDICINE

10 **Do you take, or have you taken some of the following medications?** (Tick once for each line)

	Never used	Now	Earlier	Age first time
Drugs for high blood pressure	☐	☐	☐	
Lipid lowering drugs	☐	☐	☐	
Drugs for heart disease	☐	☐	☐	
Diuretics	☐	☐	☐	
Medications for osteoporosis	☐	☐	☐	
Insulin	☐	☐	☐	
Tablets for diabetes	☐	☐	☐	
Drugs for metabolism Thyroxine/levaxin	☐	☐	☐	

11 **How often have you during the last 4 weeks used the following medications?**(Tick once for each line)

	Not used the last 4 weeks	Less than every week	Every week, but not daily	Daily
Painkillers on prescription	☐	☐	☐	☐
Painkillers non-prescription	☐	☐	☐	☐
Sleeping pills	☐	☐	☐	☐
Tranquillizers	☐	☐	☐	☐
Antidepressants	☐	☐	☐	☐

12 **State the names of all medications -both those on prescription and non-prescription drugs- you have used regularly during the last 4 weeks.** Do not include vitamins, minerals, herbs, natural remedies, other nutritional supplements, etc.

If the space is not enough for all medications, use an additional paper of your own.

When attending the survey centre you will be asked whether you have used antibiotics or painkillers the last 24 hours. If you have, you will be asked to provide the name of the drug, strength, dose and time of use.

FAMILY AND FRIENDS

13 **Who do you live with?** (Tick for each question and give the number)

	Yes	No	Number
Spouse/cohabitant	☐	☐	
Other persons older than 18 years	☐	☐	
Persons younger than 18 years	☐	☐	

14 **Tick for relatives who have or have had**

	Parents	Children	Siblings
Myocardial infarction	☐	☐	☐
Myocardial infarction before 60 years	☐	☐	☐
Angina pectoris	☐	☐	☐
Stroke/brain haemorrhage	☐	☐	☐
Osteoporosis	☐	☐	☐
Stomach/duodenal ulcer	☐	☐	☐
Asthma	☐	☐	☐
Diabetes mellitus	☐	☐	☐
Dementia	☐	☐	☐
Psychological problems	☐	☐	☐
Drugs/substance abuse	☐	☐	☐

15 **Do you have enough friends who can give you help when you need it?**

☐ Yes ☐ No

16 **Do you have enough friends whom you can talk confidentially with?**

☐ Yes ☐ No

17 **How often do you normally take part in organised gatherings, e.g. sports clubs, political meetings, religious or other associations?**

☐ Never, or just a few times a year
☐ 1-2 times a month
☐ Approximately once a week
☐ More than once a week

WORK, SOCIAL SECURITY AND INCOME

18 **What is the highest level of education you have completed?** (Tick one)

☐ Primary, 1-2 years secondary school
☐ Vocational school
☐ High secondary school (A-level)
☐ College/university less than 4 years
☐ College/university 4 years or more

19 **What is your main occupation/activity?** (Tick one)

☐ Full time work ☐ Housekeeping
☐ Part time work ☐ Retired/benefit recipient
☐ Unemployed ☐ Student/military service

20 **Do you receive any of the following benefits?**

- ☐ Old-age, early retirement or survivor pension
- ☐ Sickness benefit (are in a sick leave)
- ☐ Rehabilitation benefit
- ☐ Full disability pension
- ☐ Partial disability pension
- ☐ Unemployment benefits
- ☐ Transition benefit for single parents
- ☐ Social welfare benefits

21 **What was the households total taxable income last year?** Include income from work, social benefits and similar

- ☐ Less than 125 000 NOK
- ☐ 125 000-200 000 NOK
- ☐ 201 000-300 000 NOK
- ☐ 301 000-400 000 NOK
- ☐ 401 000-550 000 NOK
- ☐ 551 000-700 000 NOK
- ☐ 701 000 -850 000 NOK
- ☐ More than 850 000 NOK

22 **Do you work outdoors at least 25% of the time, or in cold buildings (e.g. storehouse/industry buildings)?**

- ☐ Yes
- ☐ No

PHYSICAL ACTIVITY

23 **If you have paid or unpaid work, which statement describes your work best?**

- ☐ Mostly sedentary work *(e.g. office work, mounting)*
- ☐ Work that requires a lot of walking *(e.g. shop assistant, light industrial work, teaching)*
- ☐ Work that requires a lot of walking and lifting *(e.g. postman, nursing, construction)*
- ☐ Heavy manual labour

24 **Describe your exercise and physical exertion in leisure time. If you activity varies much, for example between summer and winter, then give an average. The question refers only to the last year.** (Tick the one that fits best)

- ☐ Reading, watching TV, or other sedentary activity.
- ☐ Walking, cycling, or other forms of exercise at least 4 hours a week *(here including walking or cycling to place of work, Sunday-walking, etc.)*
- ☐ Participation in recreational sports, heavy gardening, etc. *(note:duration of activity at least 4 hours a week)*
- ☐ Participation in hard training or sports competitions, regularly several times a week.

25 **How often do you exercise?** (With exercise we mean for example walking, skiing, swimming or training/sports)

- ☐ Never
- ☐ Less than once a week
- ☐ Once a week
- ☐ 2-3 times a week
- ☐ Approximately every day

26 **How hard do you exercise on average?**

- ☐ Easy- do not become short-winded or sweaty
- ☐ You become short-winded and sweaty
- ☐ Hard- you become exhausted

27 **For how long time do you exercise every time on average?**

- ☐ Less than 15 minutes
- ☐ 15-29 minutes
- ☐ 30-60 minutes
- ☐ More than 1 hour

ALCOHOL AND TOBACCO

28 **How often do you drink alcohol?**

- ☐ Never
- ☐ Monthly or more infrequently
- ☐ 2-4 times a month
- ☐ 2-3 times a week
- ☐ 4 or more times a week

29 **How many units of alcohol** (a beer, a glass of wine or a drink) **do you usually drink when you drink alcohol?**

- ☐ 1-2
- ☐ 3-4
- ☐ 5-6
- ☐ 7-9
- ☐ 10 or more

30 **How often do you drink 6 units of alcohol or more in one occasion?**

- ☐ Never
- ☐ Less frequently than monthly
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or almost daily

31 **Do you smoke sometimes, but not daily?**

- ☐ Yes
- ☐ No

32 **Do you/did you smoke daily?**

- ☐ Yes, now
- ☐ Yes, previously
- ☐ Never

33 **If you previously smoked daily, how long is it since you stopped?**

Number of years ☐☐

34 **If you currently smoke, or have smoked before: How many cigarettes do you or did you usually smoke per day?**

Number of cigarettes ☐☐

35 **How old were you when you began smoking daily?**

Number of years ☐☐

36 **How many years in all have you smoked daily?**

Number of years ☐☐

37 **Do you use or have you used snuff or chewing tobacco?**

- ☐ No, never
- ☐ Yes, previously
- ☐ Yes, sometimes
- ☐ Yes, daily

DIET

38 **Do you usually eat breakfast every day?**

☐ Yes ☐ No

39 **How many units of fruits or vegetables do you eat on average per day?** (units means for example a fruit, a cup of juice, potatoes, vegetables)

Number of units ☐☐

40 **How many times per week do you eat hot dinner?**

Number ☐☐

41 **How often do you usually eat these products?**
(Tick once for each line)

	0-1 times/ mth	2-3 times/ mth	1-3 times/ week	4-6 times/ week	1-2 times/ day
Potatoes	☐	☐	☐	☐	☐
Pasta/rice	☐	☐	☐	☐	☐
Meat *(not processed)*	☐	☐	☐	☐	☐
Processed meat *(sausages/meatloaf/meatballs)*	☐	☐	☐	☐	☐
Fruits, vegetables, berries	☐	☐	☐	☐	☐
Lean fish	☐	☐	☐	☐	☐
Fat fish *(e.g. salmon, trout, mackerel, herring, halibut, redfish)*	☐	☐	☐	☐	☐

42 **How much do you normally drink the following?**
(Tick once for each line)

	Rarely/ never	1-6 glasses /week	1 glass /day	2-3 glasses /day	4 or more glasses /day
Milk, curdled milk, yoghurt	☐	☐	☐	☐	☐
Juice	☐	☐	☐	☐	☐
Soft drinks with sugar	☐	☐	☐	☐	☐

43 **How many cups of coffee and tea do you drink daily?** (Put 0 for the types you do not drink daily)

	Number of cups
Filtered coffee	☐☐
Boiled coffee (coarsely ground coffee for brewing)	☐☐
Other types of coffee	☐☐
Tea	☐☐

44 **How often do you usually eat cod liver and roe?** (i.e. "mølje")

☐ Rarely/never ☐ 1-3 times/year ☐ 4-6 times/year
☐ 7-12 times/year ☐ More than 12 times/year

45 **Do you use the following supplements?**

	Daily	Sometimes	No
Cod liver oil or fish oil capsules	☐	☐	☐
Omega 3 capsules *(fish oil, seal oil)*	☐	☐	☐
Vitamins and/or mineral supplements	☐	☐	☐

QUESTONS FOR WOMEN

46 **Are you currently pregnant?**

☐ Yes ☐ No ☐ Uncertain

47 **How many children have you given birth to?**

Number ☐☐

48 **If you have given birth, fill in for each child: birth year, birth weight and months of breastfeeding** (Fill in the best you can)

Child	Birth year	Birth weight in grams	Months of breastfeeding
1	☐☐☐☐	☐☐☐☐	☐☐
2	☐☐☐☐	☐☐☐☐	☐☐
3	☐☐☐☐	☐☐☐☐	☐☐
4	☐☐☐☐	☐☐☐☐	☐☐
5	☐☐☐☐	☐☐☐☐	☐☐
6	☐☐☐☐	☐☐☐☐	☐☐

49 **During pregnancy, have you had high blood pressure?**

☐ Yes ☐ No

50 **If yes, which pregnancy?**

☐ The first ☐ Second or later

51 **During pregnancy, have you had proteinuria?**

☐ Yes ☐ No

52 **If yes, which pregnancy?**

☐ The first ☐ Second or later

53 **Were any of your children delivered prematurely (a month or more before the due date) because of preeclampsia?**

☐ Yes ☐ No

54 **If yes, which child?**

1st child ☐ 2nd child ☐ 3rd child ☐ 4th child ☐ 5th child ☐ 6th child ☐

55 **How old were you when you started menstruating?**

Age ☐☐

56 **Do you currently use any prescribed drug influencing the menstruation?**

Oral contraceptives, hormonal IUD or similar ☐ Yes ☐ No

Hormone treatment for menopausal problems ☐ Yes ☐ No

When attending the survey centre you will get a questionnaire about menstruation and possible use of hormones. Write down on a paper the names of all the hormones you have used and bring the paper with you. You will also be asked whether your menstruation have ceased and possibly when and why.

Tromsø 6

- part of The Tromsø Study

FILL OUT THE FORM IN THIS WAY:

The form would be read by machine, it is therefore important that you tick appropriately:

☒ Correct

☑ Wrong

☒ Wrong

■ If you tick the wrong box, correct by filling the box like this

Write the numbers clearly 1 2 3 4 5 6 7 8 9 0

7 4 Correct

7 4 Wrong

Use only black or blue pen, do not use pencil or felt tip pen

1. DESCRIPTION OF YOUR HEALTH STATUS

Mark the statement that best fits your state of health today by ticking once in one of the boxes under each of the five groups below:

1.01 **Mobility**

- ☐ I have no problems in walking about
- ☐ I have little problems in walking about
- ☐ I am confined to bed

1.02 **Self-care**

- ☐ I have no problems with self-care
- ☐ I have some problems washing or dressing myself
- ☐ I am unable to wash or dress myself

1.03 **Usual activities** (e.g. work, study, housework, family or leisure activities)

- ☐ I have no problems with performing my usual activities
- ☐ I have some problems with performing my usual activities
- ☐ I am unable to perform my usual activities

1.04 **Pain and discomfort**

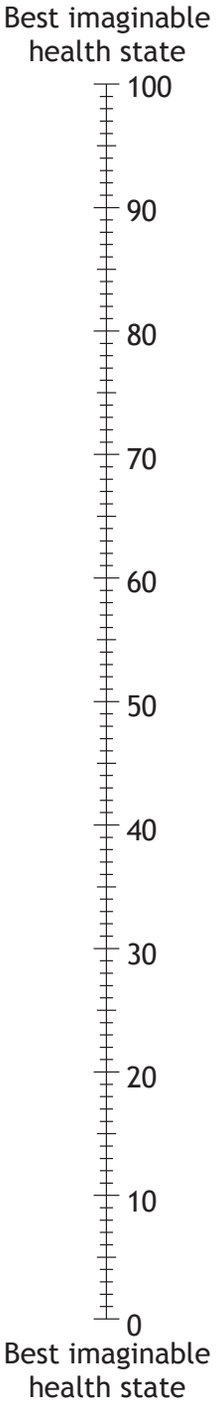
- ☐ I have no pain or discomfort
- ☐ I have moderate pain or discomfort
- ☐ I have extreme pain or discomfort

1.05 **Anxiety and depression**

- ☐ I am not anxious or depressed
- ☐ I am moderately anxious or depressed
- ☐ I am extremely anxious or depressed

1.6 To allow you to show us how good or bad your state of health is we have made a scale (almost like a thermometer) where the best state of health you can imagine is marked 100 and the worst 0. We ask you to show your state of health by drawing a line from the box below to the point on the scale that best fits your state of health.

Your own health state today



2. CHILDHOOD/YOUTH AND AFFILIATION

2.01 **Where did you live at the age of 1 year?**

- ☐ In Tromsø *(with present municipal borders)*
- ☐ In Troms, but not Tromsø
- ☐ In Finnmark
- ☐ In Nordland
- ☐ Another place in Norway
- ☐ Abroad

2.02 **How was your family's financial situation during your childhood?**

- ☐ Very good
- ☐ Good
- ☐ Difficult
- ☐ Very difficult

2.03 **What is the importance of religion in your life?**

- ☐ Very important
- ☐ Somewhat important
- ☐ Not important

2.04 **What do you consider yourself as?** (Tick for one or more alternatives)

- ☐ Norwegian
- ☐ Sami ethnicity
- ☐ Kven/Finnish
- ☐ Another ethnicity

2.05 **How many siblings and children do you have/have you had?**

Number of siblings ..... ☐☐

Number of children ..... ☐☐

2.06 **Is your mother alive?**

☐ Yes ☐ No

If NO: her age when she died ..... ☐☐

Is your father alive?

☐ Yes ☐ No

If NO: his age when he died ..... ☐☐

2.07 **What was/is the highest completed education for your parents and your spouse/cohabitant?** (Tick once for each column)

	Mother	Father	Spouse/ cohabitant
Primary 7-10 years, 1-2 years secondary school	☐	☐	☐
Vocational school	☐	☐	☐
High secondary school (A level)	☐	☐	☐
College or university (less than 4 years)	☐	☐	☐
College or university (4 years or more)	☐	☐	☐

Thank you for your help

Tromsø-undersøkelsen

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Appendix D

The first questionnaire (Q1) from Tromsø 7 and extracted pages from the second questionnaire (Q2) from Tromsø 7

The Tromsø Study
2015–2016

CONFIDENTIAL

The questionnaire will be optically read. Please, use blue or black inked pen only. Use block lettering. Refrain from the use of comma.

Date for filling in the questionnaire: ☐☐☐☐☐☐

HEALTH AND DISEASES

1.1 How do you in general consider your health to be?

Excellent	Good	Neither good nor bad	Bad	Very bad
☐	☐	☐	☐	☐

1.2 How is your health now compared to others of your age?

Excellent	Good	Neither good nor bad	Bad	Very bad
☐	☐	☐	☐	☐

1.3 Have you ever had, or do you have?
Tick once for each line.

	No	Yes, currently	Previously, not now	Age first time
High blood pressure	☐	☐	☐	☐☐
Heart attack	☐		☐	☐☐
Heart failure	☐	☐	☐	☐☐
Atrial fibrillation	☐	☐	☐	☐☐
Angina pectoris *(heart cramp)*	☐	☐	☐	☐☐
Cerebral stroke / brain haemorrhage	☐		☐	☐☐
Diabetes	☐	☐	☐	☐☐
Kidney disease, not including urinary tract infection *(UTI)*	☐	☐	☐	☐☐
Bronchitis / emphysema / COPD	☐	☐	☐	☐☐
Asthma	☐	☐	☐	☐☐
Cancer	☐	☐	☐	☐☐
Rheumatoid Arthritis	☐	☐	☐	☐☐
Arthrosis	☐	☐	☐	☐☐
Migraine	☐	☐	☐	☐☐
Psychological problems for which you have sought help	☐	☐	☐	☐☐

1.4 Do you have persistent or constantly recurring pain that has lasted for three months or more?

☐ No ☐ Yes

DENTAL HEALTH

2.1 How do you consider your own dental health to be?

	1	2	3	4	5	
Very bad	☐	☐	☐	☐	☐	Excellent

2.2 How satisfied or dissatisfied are you with your teeth or denture?

	1	2	3	4	5	
Very dissatisfied	☐	☐	☐	☐	☐	Very satisfied

USE OF HEALTH SERVICES

3.1 Have you during the past 12 months visited?

	Yes	No	Number of times
General practitioner *(GP)*	☐	☐	☐☐
Emergency room	☐	☐	☐☐
Psychiatrist / Psychologist	☐	☐	☐☐
Another medical specialist than a general practitioner *(GP)* or a psychologist or psychiatrist *(not at a hospital)*	☐	☐	☐☐
Dentist / dental services	☐	☐	☐☐
Pharmacy *(to buy / get advice about medicines / treatment)*	☐	☐	☐☐
Physiotherapist	☐	☐	☐☐
Chiropractor	☐	☐	☐☐
Acupuncturist	☐	☐	☐☐
CAM provider *(homeopath, reflexologist, spiritual healer etc.)*	☐	☐	☐☐
Traditional healer *(helper, "reader" etc.)*	☐	☐	☐☐
Have you during the past 12 months communicated with any of the services above by using the Internet?	☐	☐	☐☐

3.2 Have you over the past 12 months visited a hospital?

	Yes	No	Number of times
Hospital admission	☐	☐	☐☐
Visited an out-patient clinic:			
Psychiatric out-patient clinic	☐	☐	☐☐
Other out-patient clinics (not psychiatric department)	☐	☐	☐☐

USE OF MEDICIN

4.1 **Do you use or have you used?** *Tick once for each line.*

	Never	Now	Previously, not now	Age first time
Blood pressure lowering drugs	☐	☐	☐	
Cholesterol lowering drugs	☐	☐	☐	
Diuretics	☐	☐	☐	
Drugs for heart disease *(for example anticoagulants, antiarrhythmics, nitroglycerin)?*	☐	☐	☐	
Insulin	☐	☐	☐	
Tablets for diabetes	☐	☐	☐	
Drugs for hypothyroidism (Levaxin or thyroxine)?	☐	☐	☐	

4.2 **How often during the past four weeks have you used?** *Tick once for each line.*

	Not used in the past 4 weeks	Less than every week	Every week but not daily	Daily
Painkillers on prescription	☐	☐	☐	☐
Painkiller non-prescription	☐	☐	☐	☐
Acid suppressive medication	☐	☐	☐	☐
Sleeping pills	☐	☐	☐	☐
Tranquillizers	☐	☐	☐	☐
Antidepressants	☐	☐	☐	☐

4.3 **State the name of all medicines, both those on prescription and non-prescription drugs, you have used regularly during the last 4 weeks.** *Do not include nonprescription vitamin-, mineral- and food supplements, herbs, naturopathic remedies etc.*

If there is not enough space for all medicines, continue on a separate sheet.

DIET

5.1 **Do you usually eat breakfast every day?**

☐ No ☐ Yes

5.2 **How many units of fruit or vegetables do you eat on average per day?** *One unit is by example one apple, one salad bowl.*

Number of units

5.3 **How often do you eat these food items?** *Tick once for each line.*

	0–1 times per month	2–3 times per month	1–3 times per week	4–6 times per week	Once a day or more
Red meat (*All products from beef, mutton, pork)?*	☐	☐	☐	☐	☐
Fruits, vegetables, and berries?	☐	☐	☐	☐	☐
Lean fish *(Cod, Saithe)?*	☐	☐	☐	☐	☐
Fat fish *(salmon, trout, redfish, mackerel, herring, halibut)?*	☐	☐	☐	☐	☐

5.4 **How many glasses / containers of the following do you normally drink / eat?** *Tick once for each line.*

	Rarely / never	1–6 glasses per week	1 glass per day	2–3 glass per day	4 or more per day
Milk / Yogurt with probiotics (Biola, Cultura, Activia, Actimel, BioQ etc.)	☐	☐	☐	☐	☐
Fruit juice	☐	☐	☐	☐	☐
Soft drinks with sugar	☐	☐	☐	☐	☐
Soft drinks with artificial sweeteners	☐	☐	☐	☐	☐

5.5 **How many cups of coffee or tea do you usually drink daily?** *Put 0 for the types you <u>do not</u> drink daily.*

	Number of cups
Filtered coffee	
Boiled coffee / french plunger coffee *(coarsely ground coffee for brewing)*	
Instant coffee	
Cups of espresso-based coffee *(from coffee-machines, capsules etc.)*	
Black tea *(e.g. Earl Grey, Black currant)*	
Green tea / white tea / oolong tea	
Herbal tea *(e.g. rose hip tea, chamomile tea, Rooibos tea)*	

HEALTH ANXIETY

	Not at all	A little bit	Moderately	Quite a bit	A great deal
6.1 **Do you think there is something seriously wrong with your body?**	☐	☐	☐	☐	☐
6.2 **Do you worry a lot about your health?**	☐	☐	☐	☐	☐
6.3 **Is it hard for you to believe the doctor when he / she tells you there is nothing to worry about?**	☐	☐	☐	☐	☐
6.4 **Do you often worry about the possibility that you have a serious illness?**	☐	☐	☐	☐	☐
6.5 **If a disease is brought to your attention (e.g., on TV, radio, the internet, the newspapers, or by someone you know), do you worry about getting it yourself?**	☐	☐	☐	☐	☐
6.6 **Do you find that you are bothered by many different symptoms?**	☐	☐	☐	☐	☐
6.7 **Do you have recurring thoughts about having a disease that is difficult to be rid ofom?**	☐	☐	☐	☐	☐

PHYSICAL ACTIVITY

7.1 **If you are in paid or unpaid work, which statement describes your work best?** *Tick the most apprioate box.*

- ☐ Mostly sedentary work? *(e.g. office work, mounting))*
- ☐ Work that requires a lot of walking *(e.g. shop assistant, light industrial work, teaching)*
- ☐ Work that requires a lot of walking and lifting *(e.g. nursing, construction)*
- ☐ Heavy manual labour

7.2 **Describe your exercise and physical exertion in leisure time over the last year.** *If your activity varies throughout the year, give an average. Tick the most appropriate box.*

- ☐ Reading, watching TV / screen or other sedentary activity?
- ☐ Walking, cycling, or other forms of exercise at least 4 hours a week? (*including walking or cycling to place of work, Sunday-walking etc.)*
- ☐ Participation in recreational sports, heavy gardening, snow shoveling etc. at least 4 hours a week.
- ☐ Participation in hard training or sports competitions, regularly several times a week?

7.3 **During the last week, how much time did you spend sitting on a typical week or weekend day?** *E.g., at a desk, while visiting friends, while watching TV / screen.*

☐ Hours sitting on a weekday (both work and leisure hours*)*

☐ Hours on a weekend day

ALCOHOL

8.1 **How often do you drink alcohol??**

- ☐ Never
- ☐ Monthly or less frequently
- ☐ 2–4 times a month
- ☐ 2–3 times a week
- ☐ 4 or more times a week

8.2 **How many units of alcohol (1 beer, glass of wine or drink) do you usually drink when you drink alcohol?**

1–2	3–4	5–6	7–9	10 or more
☐	☐	☐	☐	☐

8.3 **How often do you have six or more units of alcohol in one occasion??**

- ☐ Never
- ☐ Less frequent than monthly
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or almost daily

TOBACCO and SNUFF

9.1 **Do you / did you smoke daily?**

☐ Never ☐ Yes, now ☐ Yes, previously

9.2 **Have you used or do you use snuff or chewing tobacco daily?**

☐ Never ☐ Yes, now ☐ Yes, previously

QUESTIONS ABOUT CANCER

10.1 **Have you ever had**

	No	Yes	**If yes:** Age first time	**If yes:** Age last time
A mammogram	☐	☐		
Your PSA (Prostate Specific Antigen) level measured)	☐	☐		
A colon examination (colonoscopy, stool sample test)	☐	☐		

10.2 **Has anyone in your close <u>biological</u> family ever had**

	Children	Mother	Father	Maternal grandmother	Maternal grandfather	Paternal grandmother	Paternal grandfather	Aunt	Uncle	Sibling
Breast cancer	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Prostate cancer	☐		☐		☐		☐		☐	☐
Colon cancer	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

EDUCATION AND INCOME

11.1 **What is the highest levels of education you have completed?**
Tick one box only.

- ☐ Primary / partly secondary education. *(Up to 10 years of schooling)*
- ☐ Upper secondary education: *(a minimum of 3 years)*
- ☐ Tertiary education, short: College / university less than 4 years
- ☐ Tertiary education, long: College / university 4 years or more

11.2 **What was the household's total taxable income last year?**
Include income from work, social benefits and similar.

- ☐ Less than 150 000 kr
- ☐ 150 000–250 000 kr
- ☐ 251 000–350 000 kr
- ☐ 351 000–450 000 kr
- ☐ 451 000–550 000 kr
- ☐ 551 000–750 000 kr
- ☐ 751 000 –1 000 000 kr
- ☐ More than 1 000 000 kr

FAMILY AND FRIENDS

12.1 **Who do you live with?**

	Yes	No	Number
Spouse / partner	☐	☐	
Other persons over 18 years	☐	☐	
Persons under 18 years	☐	☐	

12.2 **Do you have enough friends who can give you help and support when you need it?**

☐ Yes ☐ No

12.3 **Do you have enough friends that you can talk confidentially with?**

☐ Yes ☐ No

12.4 **How often do you take part in organised gatherings, e.g., sports clubs, political meetings, religious or other associations?**

Never, or just a few times a year	1–2 times a month	Approximately once a week	More than once a week
☐	☐	☐	☐

WOMAN ONLY

13.1 **How old were you when you first started menstruating?**

Age

13.2 **Are you pregnant at the moment?**

☐ No ☐ Yes ☐ Uncertain

13.3 **How many children have you given birth to?**

Number

13.4 **If you have given birth, how many months did you breast-feed? Fill in for each child the birth year, birth weight and the number of months breast feeding.** *Fill in the best you can*

	Birth year	Birth weight in grams	Months of breastfeeding
Child 1			
Child 2			
Child 3			
Child 4			
Child 5			
Child 6			

MEN ONLY

14.1 **Have you ever had an inflammation of your prostate / urine bladder?**

☐ No ☐ Yes

14.2 **Have you ever had a vasectomy?**

☐ No ☐ Yes **If yes:** Which year was it

Thank you for your contribution.

1 STATE OF HEALTH

For every section please mark only ONE statement, which describes the state of your health TODAY.

1.1 Mobility

I have no problem walking about
I have slight problems in walking about
I have moderate problems walking about
I have severe problems walking about
I am unable to walk about

1.2 Self-Care

I have no problems washing or dressing myself
I have slight problems washing or dressing myself
I have moderate problems washing or dressing myself
I have severe problems washing or dressing myself
I am unable to wash or dress myself

1.3 Usual activities

(I.e. work, studies, household chores, family or leisure activities)

I have no problem doing my usual activities
I have slight problems doing my usual activities
I have moderate problems doing my usual activities
I have severe problems doing my usual activities
I am unable to do my usual activities

1.4 Pain/Discomfort

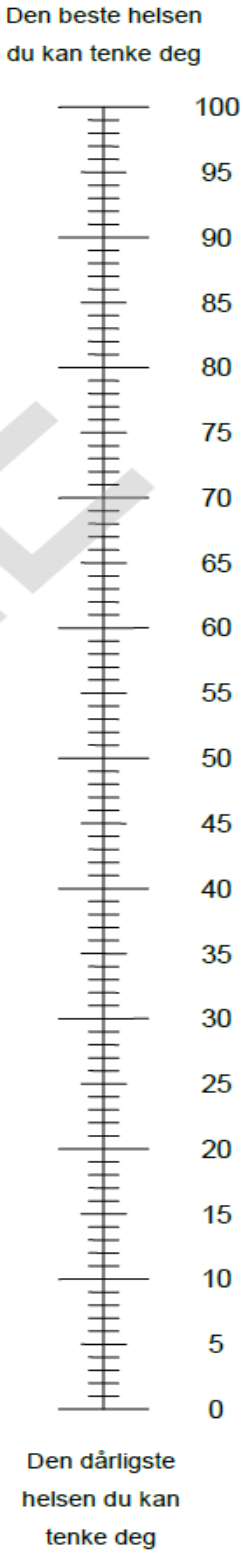
I have no pain or discomfort
I have slight pain or discomfort
I have moderate pain or discomfort
I have severe pain or discomfort
I have extreme pain or discomfort

1.5 Anxiety/Depression

I am not anxious or depressed
I am slightly anxious or depressed
I am moderately anxious or depressed
I am severely anxious or depressed
I am extremely anxious or depressed

We would like to know how good or bad your health is today. This scale is numbered from 0-100. 100 is the best health you can imagine while 0 is the worst health you can imagine. Please insert a number between 0 and 100 here.

1.6 Fill in a number between 0 and 100 which best describes your current state of health



2 CHILDHOOD/YOUTH AND AFFILIATION

2.1 Where did you live the greater part of your childhood?

(Tick once)

Tromsø

Troms, not Tromsø

Finnmark

Nordland

Norway, except Nordland, Troms, Finnmark

Abroad

2.2 How long have you lived in your current residence?

Number of years___

2.3 How was your family's financial situation during childhood?

Very good

Good

Difficult

Very difficult

2.4 What is the importance of religion in your life?

Very important

Somewhat important

No importance

2.5 What do you consider as your ethnic identity?

(Tick one or more)

Norwegian

Sami

Finnish/Kven

Other

2.6 How many siblings do you have/have you had?

Number of siblings

How many children do you have/ have you had?

Number of

Retired

Disability benefit recipient/work assessment allowance

Family income supplement

Unemployed

Student/military service

If Works full-time, Works part-time, Housekeeping, Retired, Student/military service, skip to 4.2

If Disability benefit recipient/work assessment allowance, Family income supplement, Unemployed:

4.1.1 For how long have you been without paid work?

3 months or less

4-6 months

7-12 months

1-2 years

3-5 years

6-9 years

10 years or more

4.2 I consider my occupation to have the following social status in society (if not currently employed, consider you latest occupation):

Very high social status

Fairly high social status

Neither high nor low social status

Fairly low social status

Very low status

If not Work full-time or Work part-time on 4.1 skip to 4.3

4.1.2 If working full-time or part-time, which of the following occupational fields describes your profession?

(Tick once)

Administrative leader or politician
Academic profession (at least 4 years of college or university education)
Work with shorter college or university education (1-3 years) and technicians
Office and customer service occupations
Sales-, service- and care professions
Agriculture, forestry or fisheries professions

Handyman, construction worker, skilled worker and the like
Process- and machine operator, transport worker or similar
Occupation with no formal educational requirements

4.1.2.1 Describe the workplace (department) where you were employed for the longest period of time the last 12 months (e.g. elementary school, hospital, bank)

Workplace: _____

4.1.2.2 Which occupation/title do/did you have at this workplace? (e.g. teacher, nurse)

Occupation: _____

4.1.4 If employed: On a scale from 0 to 10, how would you rate your job performance the past 7 days?

0 I have performed very poorly 10 I have performed excellently

If Work full-time or Work part-time on 4.1 skip to 5.1

If not Work full-time or Work part-time on 4.1:

4.1.3 Which of the following career fields best describes your last work?

(Tick once)

Administrative leader or politician
Academic profession (at least 4 years of college or university education)
Work with shorter college or university education (1-3 years) and technicians
Office and customer service occupations
Sales-, service- and care professions
Agriculture, forestry or fisheries professions
Handyman, construction worker, skilled worker and the like
Process- and machine operator, transport worker or similar
Occupation with no formal educational requirements

4.1.3.1 Describe the workplace (department) where you were employed for the longest period of time the last 12 months (e.g. elementary school, hospital, bank).

Workplace: _____

4.1.3.2 Which occupation/title do/did you have at this workplace? (e.g. teacher, nurse)

Occupation: _____

5 ILLNESS AND WORRIES

Have you had any of the following illnesses or worries?

No Yes Age first time

If you or your partner has received treatment for childlessness, what type of treatment have you received?

Number of times

10.1.3.1 Have you received treatment for stimulation of ovulation?
10.1.3.2 Have you received treatment for stimulation of ovulation followed by artificial insemination (not husband/partner)?
10.1.3.3 Have you received artificial insemination (not husband/partner)?
10.1.3.4 Have you received invitrofertilisation (IVF/ICSI)?
10.1.3.5 Have you received other treatment modalities for childlessness?

How many children have you got in infertility treatment:

Number of children

10.1.3.6 At the university hospital of Northern Norway?
10.1.3.7 At other treatment institutions in Norway?
10.1.3.8 Abroad?

11 FAMILY AND FRIENDS

Tick the relatives which has or have had the following disease(s)

Mother Father Children Sibling(s) None of the closest relatives

11.1 Heart attack before the age of 60
11.2 Angina pectoris (Heart cramp)
11.3 Brain hemorrhage
11.4 Asthma
11.5 Diabetes
11.6 Psychological problems
11.7 Problems with substance abuse

12 SLEEP

How many days per week

(Tick the number of days) Number for days a week 0 1 2 3 4 5 6 7

That the medicines do more harm than good

The cost of my medicines

Other

Either because of forgetfulness, inconvenience or because they do not want to, it is common that people not always take the medicine they have been prescribed. The following questions concern your habits when taking *your* medicine.

18.1.14 How many times a week do you forget to take your medicines?

Less than once a week

Once a week

2-4 times a week

5 times a week or more

18.1.15 How many times a week do you decide to miss out your medicines?

Less than once a week

Once a week

2-4 times a week

5 times a week or more

19 PHYSICAL ACTIVITY

19.1 How often do you exercise?

(i.e. walking, skiing, swimming or training/sports)

Never

Less than once a week

Once a week

2-3 times a week

Approximately every day

If Never, skip to 20.1.

If >Never:

19.1.1 If you exercise - how hard do you exercise?

Easy - you do not become shortwinded or sweaty

You become shortwinded and sweaty

Hard - you become exhausted

19.1.2 For how long time do you exercise? (give an average)

Less than 15 minutes

15-29 minutes

30-60 minutes

More than 1 hour

20 FOOD HABITS

How often do you usually eat?

Tick once for each line

0-1 times per month 2-3 times per month 1-3 times per week More than 3 times per week

20.1 Fresh water fish (not farmed)
20.2 Salt water fish (not farmed)
20.3 Farmed fish (salmon, trout, char)
20.4 Tuna fish (fresh or canned)
20.5 Fish bread spread
20.6 Mussels, shells
20.7 Brown content in crabs
20.8 Meat from whale or seal
20.9 Pluck (liver/kidney/heart) from reindeer or elk/moose
20.10 Pluck (liver/kidney/heart) from ptarmigan/grouse
20.11 Tomatoes and tomato-based products (e.g. tomato, ketchup)

How many times per year do/did you usually eat

In adulthood: times per year In childhood: times per year

20.12 "Mølje" (cod or pollack meat, liver, and roe)
20.13 Seagulls' egg
20.14 Reindeer meat
20.15 Elk meat
20.16 Wild mushroom and wild berries (blueberries/lingonberries/cloudberries)

Do you use the following food supplements?

(Tick once for each line)

No Sometimes Daily during the winter season Daily

20.17 Cod liver oil or cod liver oil capsules
20.18 Omega 3 capsules (fish oil, seal oil)
20.19 Calsium tablets
20.20 Vitamin supplement with vitamin D

No Sometimes Only while travelling Daily

Appendix E

List of links related to the Tromsø study: Tromsø 6 and 7

List of links related to the Tromsø study: Tromsø 6 and 7

Tromsø 6

Invitation to participate [Norwegian]:
https://uit.no/Content/100339/Invitasjon_deltakelse_fase_1_t6.pdf

Consent form [Norwegian]:
https://uit.no/Content/111929/Samtykke%20Tr6.pdf

The first questionnaire (Q1) in Norwegian:
https://uit.no/Content/100349/Q1_t6.pdf

The second questionnaire (Q2) in Norwegian:
https://uit.no/Content/100351/Spoerreskjema_2_t6.pdf

The full second questionnaire (Q2) in English:
https://uit.no/Content/531228/cache=20172908084211/Questionnaire_T6_2.pdf

Tromsø 7

Invitation to participate [Norwegian]:
https://uit.no/Content/710341/cache=20203011123325/brosjyre.tromsø7.pdf

Consent form:
https://uit.no/Content/575211/cache=20180805144729/Samtykke.den7.Tromsoundersokelsen.pdf

The first questionnaire Q1 in Norwegian:
https://uit.no/Content/710342/cache=20203011123337/Q1%2BTromsø%2B7.pdf

The second questionnaire Q2 in Norwegian:
https://uit.no/Content/710352/cache=20203011124130/Q2%2BTromsø7.pdf

The full second questionnaire Q2 in English:
https://uit.no/Content/709325/cache=20202011171303/FINAL%20Q2%20translation201903
07.pdf

Appendix F

Questionnaire SEP Survey (Section C), including information about the study and consent form, Australia

Default Question Block

EXPLANATORY STATEMENT

Project ID: 17490

Project title: Investigating people's views on socio-economic position

Associate Professor Gang Chen	***Professor Jan Abel Olsen***
Centre for Health Economics	*Department of Community Medicine*
Monash University, Australia	*University of Tromsø, Norway*
Phone: +61 39905 0502; 0425 811 029	*Phone: +47 7764 4832*
Email: gang.chen@monash.edu	*Email: jan.abel.olsen@uit.no*

You are invited to take part in this study. Please read this Explanatory Statement in full before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the phone numbers or email addresses listed above.

What does the research involve?

People differ in terms of their socio-economic position in society. Positions in society is often associated with individual's education, occupation and income. The relative importance of these factors may differ across cultures and countries. The purpose of this study is to find out what factors you think determine a person's socio-economic position, or their status in society.

If you are willing to help us with this research project, we would be grateful for your assistance with completing an online questionnaire. The questionnaire contains three main sections. Section A involves a series of pairwise comparison tasks to understand participants' preferences on how education, occupation and income determine a person's socio-economic position in society. Section B contains validated instruments measuring participants' own health and subjective wellbeing. Second C contains participants' personal backgrounds. We expect that this questionnaire will take no more than 20 minutes to complete.

Please note that the survey is compatible for PC and laptops only (and not mobiles).

Why were you chosen for this research?

You have been invited because we would like to understand and compare the views held by representative samples of people from different countries.

You have been contacted by your panel company. The company is sending you this questionnaire based on the information you have provided. The researchers do not have access to your personal information.

Source of funding

The project is being funded by the University of Tromsø in Norway, and Monash University in Australia.

Consenting to participate in the project and withdrawing from the research

Following the online informed consent, you indicate that you understand the information and that you give your consent to participate in this research project. Participation in this study is voluntary and you may refuse to answer any questions or withdraw at any time. However, after submitting the survey online, you will not be able to revise the result or withdraw from the study since all responses will be anonymised.

All information collected will remain confidential and seen only by the researchers involved. Participants will not and could not be identified in any publication.

Possible benefits and risks to participants

There is unlikely to be any direct benefit to you personally from taking part in this study.

We do not anticipate that you will be exposed to any risk by taking part in this study. The methods we used to understand your preferences have been used widely in other contexts. However, some people could find answering some of the questions uncomfortable. If this happens you may choose to withdraw from the study or speak to the project psychologist, Dr Aimee Maxwell, on 0456 033 200. If you are distressed as a result of any questions feel free to contact Dr Maxwell. Dr Maxwell has no other role in the project.

Payment

You will be reimbursed by your panel company.

Confidentiality

The online survey responses will be transferred to a secure password protected spreadsheet, the password being known only to the chief investigators working on the project and their nominated staff. All responses will be anonymised. You will not be identifiable by name in any presentation or publication arising from the results of the survey.

Storage of data

All the information collected by the project will be stored on the Monash University server and University of Tromsø server and on computers in locked offices at the Centre for Health Economics at Monash University and Department of Community Medicine at University of Tromsø. The data will be kept for 10 years from publication. After this time the information will be destroyed by Monash University and University of Tromsø.

Results

The results of this study will be submitted for presentations in conferences and for publication in research journals. You will not be provided with the results of the study since all responses will be anonymised.

Complaints

Should you have any concerns or complaints about the conduct of the project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics Committee (MUHREC):

Executive Officer
Monash University Human Research Ethics Committee (MUHREC)
Room 111, Chancellery Building D,
26 Sports Walk, Clayton Campus
Research Office
Monash University VIC 3800

Tel: +61 3 9905 2052 *Email: muhrec@monash.edu* *Fax: +61 3 9905 3831*

Thank you,

Associate Professor Gang Chen
Monash University

Professor Jan Abel Olsen
University of Tromsø

CONSENT FORM

Project ID: 17490
Project title: Investigating people's views on socio-economic position

Chief Investigator: Associate Professor Gang Chen & Professor Jan Abel Olsen

I have been asked to take part in the Monash University and University of Tromsø research project specified above. I have read and understood the Explanatory Statement and I hereby consent to participate in this project.

- I understand that my participation is voluntary, and that I can withdraw at any stage of the project without being penalised or disadvantaged in any way. However, after submitting the survey online, you will not be able to revise the result or withdraw from the study since all responses will be anonymised.
- I understand that any information I provide is confidential, and that no information that could lead to the identification of any individual will be disclosed in any reports on the project, or to any other party.

- I understand that data from this online survey will be kept in a secure storage and accessible to the research team.

I AGREE TO PARTICIPATE	I DO NOT AGREE TO PARTICIPATE
○	○

Block 1

Investigating people's views on socio-economic position

Please remember: It is important that you try and answer all the questions. You do not have to show your answers to anybody. Also, nobody who knows you will look at your questionnaire once you have finished it. Please be open and honest in your responding.

Section A – Choice experiments

In the pairwise comparisons that follow, you will be faced with many different combinations of education, occupation and income levels. Each of these are described using four levels, see the table below.

Characteristics	Examples/Explanations
Education Levels	
Postgraduate Degree	i.e. Graduate degrees, long university education; such as Bachelor Honours Degree, Graduate Certificate/Diploma, Masters Degree, Doctoral Degree
Bachelor Degree	i.e. Undergraduate Degree
Certificate or Diploma	e.g. Certificate I-IV level, Diploma, Advanced Diploma, Associate Degree
Primary or Secondary School	
Occupation Levels	

Managers & professionals	e.g. Executives and General Managers; Hospitality, Retail and Service Managers; Health and Education Professionals
Technicians & trades workers	e.g. Engineering and Science Technicians; Automotive, Engineering, Construction, and Telecommunications Trades Workers
Sales, clerical & service workers	e.g. Sales Representatives; Program Administrators and Secretaries; Health and Welfare Support Workers; Sports and Personal Service Workers
Machinery operators, drivers & labourers	e.g. Machine and Stationary Plant Operators; Road and Rail Drivers; Construction and Mining Labourers; Farm, Forestry and Garden Workers
Gross Annual Household Income	
$ 220,000	Gross income is the sum of income from all sources before income tax and the Medicare levy have been deducted. Household income contains the combined income of everyone in your household.
$ 130,000	
$ 85,000	
$ 35,000	

In each of the pairwise comparisons presented below, we would like to know whom **in your view** has a higher socio-economic status. There is no right or wrong answers to these questions.

Example: In the following pairwise comparison, the respondent regards Person B has a higher socio-economic status than Person A.

	Person A	Person B
Education	Postgraduate Degree	Bachelor Degree
Occupation	Technicians & trades workers	Machinery operators, drivers & labourers
Gross annual household income ($)	130,000	220,000

Person A ○ Person B ○

B

Section B – Your personal wellbeing and health

The following nine questions ask how satisfied you feel, on a scale from zero to 10. **Zero** means you feel no satisfaction at all and **10** means you feel completely satisfied.

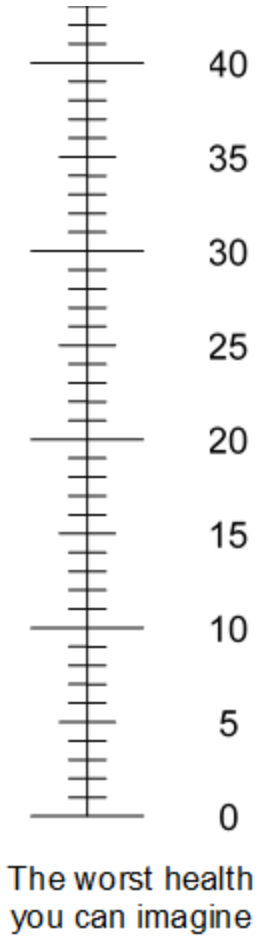
B1

B1.1. "Thinking about your own life and personal circumstances, how satisfied are you **with your life as a whole** ?"

No satisfaction at all — Completely Satisfied

0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○

B1.2. "How satisfied are you **with your standard of living** ?"



YOUR HEALTH TODAY =

C

Section C – Personal background

Finally, we would like to ask some questions about your background:

C1. Your are

- ○ Female
- ○ Male

C2. Your age: (years)

C3. Which of these best describes your current marital status?

- Married/living together
- In a relationship, but not living together
- Widowed
- Single
- Divorced/Separated

C4. How many persons are there in your household:

C5. Your home postcode:

C6. Were you born in Australia?

- Yes
- No

C7. Do you have any long-term health condition, impairment or disability that restricts you in your everyday activities, and has lasted or is likely to last, for 6 months or more?

- Yes
- No
- Don’t know

C8. Think of this ladder as representing where people stand in society.

At the top of the ladder are the people who are best off – those who have the most money, most education and the best jobs. At the bottom are the people who are worst off – who have the least money, least education and the worst jobs or no job. The higher up you are on this ladder, the closer you are to people at the very top and the lower you are, the closer you are to the bottom.

Where would you put yourself on the ladder:

C9. Please choose the level that best describes your own education:

- Postgraduate Degree
- Bachelor Degree
- Certificate or Diploma
- Primary or Secondary School

C10. Please tick the level that best describes your own occupation. If you are retired, please tick the level that best describes your latest occupation:

- Managers & professionals
- Technicians & trades workers

- ○ Sales, clerical & service workers
- ○ Machinery operators, drivers & labourers
- ○ Not in the workforce (e.g. student, unemployed, homeworker)

C11. Please tick the level that best describes your pre-tax or gross annual **personal** income:

- ○ $ 150,001 and above
- ○ $ 125,001 – $ 150,000
- ○ $ 90,001 – $ 125,000
- ○ $ 75,001 – $ 90,000
- ○ $ 60,001 – $ 75,000
- ○ $ 50,001 – $ 60,000
- ○ $ 40,001 – $ 50,000
- ○ $ 30,001 – $ 40,000
- ○ $ 20,001 – $ 30,000
- ○ $ 20,000 or less

C12. Please tick the level that best describes your pre-tax or gross annual **household** income:

- ○ $ 220,001 and above
- ○ $ 160,001 – $ 220,000
- ○ $ 130,001 – $ 160,000
- ○ $ 100,001 – $130,000
- ○ $ 85,001 – $100,000
- ○ $ 65,001 – $ 85,000
- ○ $ 50,001 – $ 65,000
- ○ $ 35,001 – $ 50,000
- ○ $ 25,001 – $ 35,000
- ○ $ 25,000 or less

C13. If you were to compare your income with the average income of other people that you would normally socialize with (e.g. friends, colleagues, neighbours), would you say your income is higher

or lower:

- Higher
- Slightly higher
- About the same
- Slightly lower
- Lower

C14. How was your family's financial situation during your childhood?

- Very good
- Good
- Neither good nor bad
- Difficult
- Very difficult

C15. What is/was your father's highest education level?

- Postgraduate Degree
- Bachelor Degree
- Certificate or Diploma
- Primary or Secondary School

C16. What is/was your mother's highest education level?

- Postgraduate Degree
- Bachelor Degree
- Certificate or Diploma
- Primary or Secondary School

c1

C17. Among the following six characteristics, please indicate their importance when you judge a person's socio-economic status.

In each of the three columns, please tick **ONE** box for which characteristic you consider **Most important**, **Second most important** and **Least important.**

	Most important	Second most important	Least important
Education	☐	☐	☐
Occupation	☐	☐	☐
Personal income	☐	☐	☐
Household income	☐	☐	☐
Neighbourhood where the person lives	☐	☐	☐
Parents' socio-economic position	☐	☐	☐

c3

C17. Among the following six characteristics, please indicate their importance when you judge a person's socio-economic status.

Imagine the person is a woman, in each of the three columns, please tick **ONE** box for which characteristic you consider **Most important**, **Second most important** and **Least important.**

	Most important	Second most important	Least important
Education	☐	☐	☐
Occupation	☐	☐	☐
Personal income	☐	☐	☐
Household income	☐	☐	☐
Neighbourhood where the person lives	☐	☐	☐
Parents' socio-economic position	☐	☐	☐

c2

C17. Among the following six characteristics, please indicate their importance when you judge a person's socio-economic status.

Imagine the person is a man, in each of the three columns, please tick **ONE** box for which characteristic you consider **Most important**, **Second most important** and **Least important.**

	Most important	Second most important	Least important
Education	☐	☐	☐
Occupation	☐	☐	☐
Personal income	☐	☐	☐
Household income	☐	☐	☐
Neighbourhood where the person lives	☐	☐	☐
Parents' socio-economic position	☐	☐	☐

END

Thank you very much for taking the time to complete this survey!

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Appendix G

Questionnaire SEP Survey (Section C), including information about the study and consent form, Norway [Norwegian]

Default Question Block

Forklaring

Prosjekt: Undersøkelse: Hva er avgjørende for folks sosio-økonomiske status?

Prosjektansvarlig

Senter for helseøkonomi, Monash University, Australia *Professor G Chen*

Institutt for samfunnsmedisin, Universitetet i Tromsø *Professor JA Olsen*

E-post jan.abel.olsen@uit.no

Du er invitert til å delta i denne studien. Vær vennlig å lese forklaringen før du bestemmer deg for om du vil delta. Dersom du vil ha ytterligere informasjon, kan du kontakte forskerne via den oppgitte e-post adressen.

Hva innebærer dette prosjektet?

Folks sosio-økonomiske posisjon i samfunnet er ulik, og vil som regel avhenge av personens utdanning, yrke og inntekt. Den relative betydningen av disse faktorene varierer mellom land og kulturer. Hensikten med denne studien er å finne ut hvilke faktorer du tenker er avgjørende når du vurderer folks sosio-økonomiske posisjon, eller deres status i samfunnet.

Hvis du er villig til å delta i dette forskningsprosjektet, ber vi deg fylle ut et spørreskjema som har tre deler. Del A er en serie parvise sammenlikninger for å forstå deltakernes syn på hvordan utdanning, yrke og inntekt bestemmer sosio-økonomiske status. Del B inneholder noen standardiserte spørsmål om egen helse og velvære. Del C spør om deltakernes bakgrunn.

Spørreskjemaet forventes å ikke ta mer enn 20 minutter å fylle ut. Det er bare kompatibel for PC og nettbrett (ikke mobil-telefon).

Hvorfor ble du invitert til å delta?

Du er invitert til å delta fordi vi vil sammenlikne ulike syn på dette temaet i ulike land. I hvert land trenger vi 900 deltakere over 18 år. Du har blitt kontaktet av ditt panel byrå, basert på opplysninger du allerede har oppgitt mht alder og kjønn. Forskerne har ikke tilgang til noen personidentifiserbare data om deg.

Samtykke

- Jeg har lest Online deltaker informasjon og er enig i å delta i forskningsprosjektet.
- Min deltakelse er frivillig, og jeg kan trekke meg på hvilket som helst tidspunkt
- All informasjon jeg gir er konfidensiell, og ingen informasjon som kan føre til identifikasjon av en person vil bli avslørt i rapporter fra prosjektet.
- Data fra denne online undersøkelsen vil bli holdt i en sikker lagring og kun tilgjengelig for forskningsgruppen

Mulig nytte og risiko for deltakerne

Det er usannsynlig at du vil ha noen personlig nytte av å delta i denne studien. Det er også usannsynlig at spørsmålene innebærer noe ubehag. Metodene og spørsmålene som inngår har tidligere vært brukt i andre sammenhenger.

Lagring av data

All innsamlet informasjon vil bli lagret på server hos Monash Universitet, og bli slettet etter 10 år.

Resultater

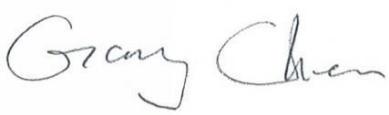
Resultatene fra studien vil bli presentert på konferanser og i forskningstidsskrift, og formidlet i media.

Klager

Dersom du har noe du vil klage på, er du velkommen til å rette disse til:

Thor Klaussen, Universitetet i Tromsø, tel: 95745405, e-post: thor.klaussen@uit.no

Professor Jan Abel Olsen
Institutt for Samfunnsmedisin
Universitetet i Tromsø



Professor Gang Chen
Senter for helseøkonomi
Monash University, Australia

Samtykke skjema

Project ID: 17490
Prosjekt tittel: Undersøkelse av folks syn på hva som bestemmer sosio-økonomiske status
Prosjektledere: Professor Gang Chen & Professor Jan Abel Olsen

Jeg har blitt spurt om å delta i et forskningsprosjekt i regi av Universitet i Tromsø og Monash University li Australia. *Jeg har lest og forstått deltaker informasjonen og samtykker herved at jeg deltar.*

- **Min deltakelse er frivillig, og jeg kan trekke meg på hvilket som helst tidspunkt. Etter at spørreskjemaet er sendt inn, kan jeg ikke revidere eller endre på noe fordi alle svar er anonyme.**
- **All informasjon jeg gir er konfidensiell, og ingen informasjon som kan føre til identifikasjon av en person vil bli avslørt i rapporter fra prosjektet eller til noen andre.**
- **Data fra denne online undersøkelsen vil bli lagret på et sikkert sted og kun være tilgjengelig for forskningsgruppen.**

Jeg er villig til å delta	Jeg er ikke enig i å delta
○	○

Block 1

Hva mener du er avgjørende for folks' sosio-økonomiske status

Husk: Det er viktig at du besvarer alle spørsmål. Du trenger ikke vise svarene til noen. Ingen som kjenner deg vil ha tilgang til dine svar. Vær så åpen og ærlig som mulig når du svarer.

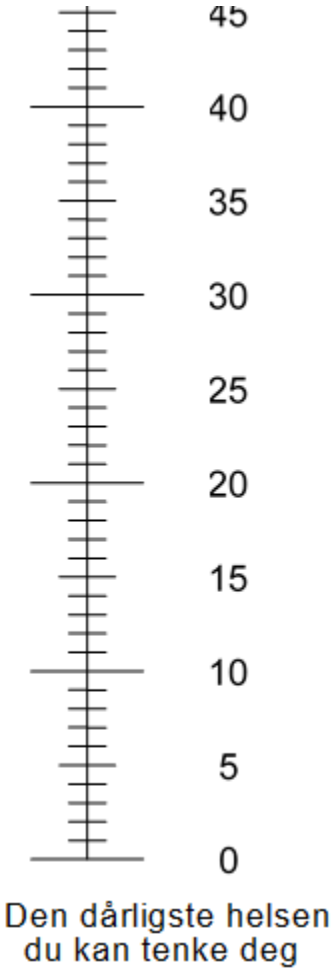
Del A – Valg eksperiment

I de parvise valgene som følger vil du bli presentert med flere ulike kombinasjoner av utdanning, yrke og inntekt. Disse vil bli beskrevet langs fire nivå som i tabellen nedenfor.

Kjennetegn	Eksempler / forklaringer
Utdanning	
Høyskole/universitet, 4 år eller mer	Tilsvarer mastergrad, hovedfag, dr.grad
Høyskole/universitet, mindre enn 4 år	Tilsvarer bachelorgrad, 3-årige høgskoleutdanninger
Videregående/fagutdanning, 3 år	Tilsvarer videregående skole, fagbrev
Grunnskole/framhaldsskole inntil 10 år	
Yrke	
Ledere, eller akademiske yrker	f.eks. lege, lektor
Høyskoleyrker og militære yrker	f.eks. sykepleier, politi
Kontor-, salgs- og service yrker	f.eks. salgskonsulent, frisør
Håndverkere, maskinoperatører, arbeidere	f.eks. prosessoperatør, sjåfør, renholder
Total brutto husholdningsinntekt	
1,400,000	Brutto årlig inntekt fra alle kilder før skatt
1,000,000	
700,000	
350,000	

I hvert av de parvise valgene vil vi vite hvem av Person A eller Person B som du mener har den høyeste sosio-økonomiske posisjon eller status i samfunnet. Det er ingen riktige eller gale svar på disse spørsmålen

Eksempel: I den følgende parvise sammenlikningen, tenker respondenten at Person B har høyere sosio-økonomisk status enn Person B



HELSEN DIN I DAG =

C

Del C – Din bakgrunn

Til slutt vil vi gjerne stille noen spørsmål om din bakgrunn:

C1. Er du

- ○ Kvinne
- ○ Mann

C2. Din alder: (år)

C3. Hva beskriver best din sivile status?

- Gift/samboende
- I et forhold, men bor ikke sammen
- Enslig
- Enke/enkemann
- Skilt/separert

C4. Hvor mange personer er det i din husholdning?:

C5. Postnummer der du bor:

C6. Er du født i Norge?

- Ja
- Nei

C7. Har du noen kronisk sykdom eller funksjonshemming som begrenser dine daglige aktiviteter, og som du har hatt (eller kan forventes å ha) i minst 6 måneder?

- Ja
- Nei
- Vet ikke

C8. Tenk deg at denne stigen viser hvilken posisjon folk har i samfunnet.

På toppen av stigen er de som er best stilt – de som har mest penger, høyest utdanning og de beste jobbene. På bunnen av stigen er de som er dårligst stilt – de som har minst penger, lavest utdanning og de dårligste jobbene eller ingen jobb. Desto høyere du befinner deg på denne stigen, desto nærmere er du folk som er på toppen, og desto lavere du befinner deg, desto nærmere er du bunnen

Hvor vil du plassere deg selv på denne stigen

C9. Hva er din høyeste fullførte utdanning:

- ○ Høyskole/universitet, 4 år eller mer
- ○ Høyskole/universitet, mindre enn 4 år
- ○ Videregående/gymnas/fagutdanning, minimum 3 år
- ○ Grunnskole/framhaldsskole inntil 10 år

C10. Merk det som best beskriver ditt yrke. Hvis du er pensjonist, klikk det som best beskriver ditt siste yrke

- Ledere, og akademiske yrker
- Høyskoleyrker og militære yrker
- Kontor-, salgs- og service yrker
- Bønder, fiskere
- Håndverkere, prosess- og maskinoperatører, transportarbeider, renholdere, hjelpearbeidere
- Ikke i arbeidslivet (f.eks. student, hjemmearbeidende, sykemeldt, arbeidsløs)

C11. Hvor høy var din **personlige** bruttoinntekt siste år: (Ta med alle inntekter fra arbeid, trygder, sosialhjelp og lignende)

- 1,000,000 eller mer
- 800,000 – 999,000
- 600,000 – 799,000
- 400,000 – 599,000
- 200,000 – 399,000
- 199,000 eller mindre

C12. Hvor høy var **husholdningens** samlede bruttoinntekt siste år? (Ta med alle inntekter fra arbeid, trygder, sosialhjelp og lignende)

- 1,400,000 eller mer
- 1,200,000 – 1,399,000
- 1,000,000 – 1,199,000
- 850,000 – 999,000
- 700,000 – 849,000
- 500,000 – 699,000
- 350,000 – 499,000
- 349,000 eller mindre

C13. Hvis du skulle sammenlikne din inntekt med inntekten til folk som du omgås (venner, kolleger, naboer), vil du si at din inntekt er høyere eller lavere enn gjennomsnittet blant de du omgås?

- Høyere
- Litt høyere
- Omtrent som de andre
- Litt lavere
- Lavere

C14. Hvordan var de økonomiske forhold i familien din under din oppvekst?

- Meget gode
- Gode
- Hverken gode eller vanskelige
- Vanskelige
- Meget vanskelige

C15. Hva var/er din **fars** høyeste fullførte utdanning

- Høyskole/universitet, 4 år eller mer
- Høyskole/universitet, mindre enn 4 år
- Videregående/gymnas/fagutdanning, minimum 3 år
- Grunnskole/framhaldsskole inntil 10 år

C16. Hva var/er din **mors** høyeste fullførte utdanning

- Høyskole/universitet, 4 år eller mer
- Høyskole/universitet, mindre enn 4 år
- Videregående/gymnas/fagutdanning, minimum 3 år
- Grunnskole/framhaldsskole inntil 10 år

c1

C17. Blant de følgende seks karakteristika ber vi deg markere deres viktighet når du vurderer en persons sosio-økonomiske posisjon eller status i samfunnet.

I hver av kolonnene nedenfor ber vi deg markere dette ved å sette ett kryss for henholdsvis **Mest viktig, Nest mest viktig,** og **Minst viktig**.

	Mest viktig	Nest mest viktig	Minst viktig
Utdanning	☐	☐	☐
Yrke	☐	☐	☐
Personlig inntekt	☐	☐	☐
Husholdnings inntekt	☐	☐	☐
Nabolaget der man bor	☐	☐	☐
Foreldrenes sosio-økonomiske posisjon	☐	☐	☐

c3

C17. Blant de følgende seks karakteristika ber vi deg markere deres viktighet når du vurderer en persons sosio-økonomiske posisjon eller status i samfunnet.

Tenk deg at denne personen er en kvinnel hver av kolonnene nedenfor ber vi deg markere dette ved å sette ett kryss for henholdsvis **Mest viktig, Nest mest viktig,** og **Minst viktig**.

	Mest viktig	Nest mest viktig	Minst viktig
Utdanning	☐	☐	☐
Yrke	☐	☐	☐
Personlig inntekt	☐	☐	☐
Husholdnings inntekt	☐	☐	☐
Nabolaget der man bor	☐	☐	☐
Foreldrenes sosio-økonomiske posisjon	☐	☐	☐

c2

C17.Blant de følgende seks karakteristika ber vi deg markere deres viktighet når du vurderer en persons sosio-økonomiske posisjon eller status i samfunnet.

Tenk deg at denne personen er en mann hver av kolonnene nedenfor ber vi deg markere dette ved å sette ett kryss for henholdsvis **Mest viktig, Nest mest viktig,** og **Minst viktig**.

	Mest viktig	Nest mest viktig	Minst viktig
Utdanning	☐	☐	☐
Yrke	☐	☐	☐
Personlig inntekt	☐	☐	☐
Husholdnings inntekt	☐	☐	☐
Nabolaget der man bor	☐	☐	☐
Foreldrenes sosio-økonomiske posisjon	☐	☐	☐

END

Tusen takk for at du tok deg tid til å fullføre denne undersøkelsen!