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Doctoral thesis

Sofie Lauvås Hjorthen

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The HUNT Study, Norway

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of Philosophiae Doctor
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Helse i kystsamfunn: Generasjonelle og sosiale ulikheter i helse i en periode preget av samfunnsmessig omstrukturering. HUNT-undersøkelsen, Norge.

Hvordan utvikler kystbefolkningens helse seg i en tid med store samfunnsendringer?

Fra og med de siste tiårene av 1900-tallet har omfanget av småskalafisket blitt betydelig redusert verden over. Dette skyldes i stor grad drivkrefter som overfiske, klimaendringer og nyliberalistiske vendinger i fiskeripolitikken. Denne utviklingen er også tydelig i Norge, hvor mange rurale kystsamfunn har gjennomgått en betydelig samfunnsmessig omforming som følge av reduserte fangstmengder, nye reguleringer i havforvaltningen og en betydelig nedgang i fiskeflåten.

Samfunnsmessige omstruktureringer kan ha konsekvenser for helsa i en befolkning. Derfor kan nedgangen i en sentral næring i norske kystsamfunn anses som et naturlig eksperiment på befolkningsnivå, og er slik sett av stor interesse for sosialepidemiologiske studier. Nåværende kunnskap om kystbefolkningens helse under omstruktureringene i fiskeindustrien er begrenset. Denne avhandlingen søker derfor å undersøke utviklingen i befolkningshelsa i en norsk kystbefolkning som tidligere har hatt en betydelig aktivitet i småskalafiske.

Vi har brukt data fra Helseundersøkelsen i Trøndelag (HUNT) samlet inn over fire tiår: 1984–1986 (HUNT1), 1995–1997 (HUNT2), 2006–2008 (HUNT3) og 2017–2019 (HUNT4). Kommunene i utvalget ble klassifisert som enten rural kyst-, urban kyst-, rural fjord- eller rural innlandsbefolkning. Hovedfokus i denne avhandlingen er den rurale kystbefolkningen. Helsemålet som undersøkes er selvopplevd helse.

Resultatene av dette arbeidet viser at den rurale kystbefolkningen rapporterer dårligere selvopplevd helse enn befolkningen i andre geografiske områder gjennom alle de fire tiårene denne studien tar for seg. Likevel fant vi at helsa i den rurale kystbefolkningen har forbedret seg gjennom perioden, og at ulikhetene i helse mellom de geografiske områdene har blitt mindre. Videre fant vi at sosiale ulikheter i selvopplevd helse har minket i den rurale kystbefolkningen gjennom perioden.

Selv om man ikke kan tilskrive denne forbedringen i kysthelse til spesifikke omstrukturerings-prosesser, kan man tenke seg at overgangen fra småskalafisket til andre sysselsettings-muligheter kan ha medført gunstige endringer i arbeidsforholdene for mange av beboerne i disse områdene. Det er uansett et betydningsfullt funn at ulike populasjoner som lever ved kystlinja (kyst- og fjordkommuner) utviser ulik helse på populasjonsnivå. Dette understreker heterogeniteten i det vi anser som kystbefolkning, og bidrar med ny kunnskap og nyanser i forskningen på kysthelse.

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Trondheim, November 2022

Sofie Lauvås Hjorthen

List of Papers

This thesis is based on the following papers:

Paper I

Hjorthen, S. L., Sund, E. R., Skalická, V., & Krokstad, S. (2020). Understanding coastal public health: Employment, behavioural and psychosocial factors associated with geographical inequalities. The HUNT study, Norway. *Social Science & Medicine, 264*, 113286.

Paper II

Hjorthen, S. L., Sund, E. R., Kjørholt, A. T., Engevold, M. H., & Krokstad, S. (2021). Public health in restructuring coastal communities: Generational trends in self-rated health following the decline in small-scale fishing. The HUNT study, Norway. *Journal of Rural Studies, 88*, 307-316.

Paper III

Hjorthen, S. L., Sund, E. R., Skalická, V., Eikemo, T. A., Getz, L. O., & Krokstad, S. (2022). Trends in absolute and relative educational inequalities in health during times of labour market restructuring in coastal areas: The HUNT Study, Norway. *Social Science & Medicine, 292*, 114541.

List of abbreviations

APR	Adjusted predictions at representative values
CI	Confidence interval
FIML	Full information maximum likelihood
HADS	Hospital Anxiety and Depression Scale
HADS-A	Anxiety subscale of the Hospital Anxiety and Depression Scale
HADS-B	Depression subscale of the Hospital Anxiety and Depression Scale
HUNT	The Trøndelag Health Study, former The Nord-Trøndelag Health Study (1984-2019)
HUNT1	The Nord-Trøndelag Health Study, survey 1 (1984-1986)
HUNT2	The Nord-Trøndelag Health Study, survey 2 (1995-1997)
HUNT3	The Nord-Trøndelag Health Study, survey 3 (2006-2008)
HUNT4	The Nord-Trøndelag Health Study, survey 4 (2017-2019)
ISCED11	International Standard Classification of Education 2011
ISCO-88	International Standard Classification of Occupations
MAR	Missing at random
MCAR	Missing completely at random
MER	Marginal effects at representative values
MNAR	Missing not at random
NOU	Official Norwegian Reports
NUS2000	The Norwegian Standard Classification of Education
NSD	Norwegian centre for research data
NTNU	Norwegian University of Science and Technology

OECD	Organization for Economic Co-operation and Development
OR	Odds ratio
REC	Regional Committee for Medical and Health Research Ethics
RII	Relative index of inequality
SII	Slope index of inequality
SSB	Statistics Norway
UK	United Kingdom
US	United States

List of figures and tables

Summary

Background and aims: In the latter decades of the 20th century, many small-scale fisheries worldwide have decreased or disappeared. Important driving forces behind this development are overfishing, climate change and neoliberal policy shifts in fishing. This decline is seen in Norway, where many rural coastal communities have undergone a substantial societal restructuring due to plummeting fish stocks, new aquatic regulations and a substantial decrease in the fishing fleet concurrent with technological development in fishing gear.

Societal restructuring can be intertwined with the health of its population. Therefore, the observed decline in a crucial industry in Norwegian coastal communities can be considered a natural experiment at the population level and is therefore of significant interest for social-epidemiological studies. Present knowledge on the health of coastal populations during the fishing industry restructuring is limited. Thus, the overall aim of this thesis is to examine the health situation and decennial health trends in a Norwegian rural coastal population with a former dependence on small-scale fishing. The specific aims of this thesis are to examine the association of geographical affiliation and self-rated health as well as investigate the contributions of employment, behavioural and psychosocial factors to this association (Paper I); to study trends in self-rated health in three generations over four decades (Paper II) as well as trends in absolute and relative educational inequalities in self-rated health (Paper III) in a rural coastal population and compare findings with adjacent areas.

Methods: The data were obtained from four cycles of The Trøndelag Health Study (The HUNT Study), a population-based cross-sectional health survey conducted in the northern part of Trøndelag County in Central Norway. The four cycles of data collection occurred in 1984–1986 (HUNT1), 1995–1997 (HUNT2), 2006–2008 (HUNT3) and 2017–2019 (HUNT4). In all three papers, the study population were classified as either rural coast, urban coast, rural fjord or rural inland inhabitants. The outcome in the three papers was self-rated health (dichotomised into good and poor self-rated health). Paper I is a cross-sectional study (HUNT3) based on logistic regression and includes participants aged 20 years and older. Papers II and III are repeated cross-sectional studies (HUNT1–HUNT4) based on Poisson regressions and include participants aged 20 and 30 years and older, respectively.

Results: The rural coastal population exhibited greater odds of reporting poor self-rated health than those in other areas (urban coast, rural inland and rural fjord). This finding remained when simultaneously controlling for age and gender as well as employment, behavioural and psychosocial factors. Of the employment, behavioural and psychosocial factors, behavioural factors were found to contribute most to poor rural coastal self-rated health, closely followed by employment factors. Nevertheless, the majority of the association between rural coastal affiliation and poor health remains after controlling for these factors. The rural coastal population exhibited a higher predicted prevalence of poor self-rated health in adults and the elderly compared with those in adjacent geographical areas across the four decades. However, the health gaps narrowed between the rural coastal population and the adjacent populations in these age groups over the course of the HUNT surveys. Developments in educational inequalities in self-rated health were generally more favourable in the rural coastal population; relative educational inequalities in self-rated health have decreased steadily in the rural coastal population over the course of the HUNT surveys.

Conclusions: The rural coastal areas studied in this thesis have undergone substantial societal restructuring following the decline in small-scale fishing. Findings reveal that the rural coastal population exhibited poorer health than those in other areas across the four decades of this study. Nonetheless, the health of the rural coastal population has improved and health gaps between areas have narrowed. Moreover, educational inequalities in health have decreased in this rural coastal population. Although one cannot attribute the improvement in rural coastal health to specific restructuring processes, the shift from small-scale fishing to alternative employment opportunities may have improved the general working conditions for many inhabitants in these areas.

1 Introduction

Coastal settlements are widespread and substantial in total size. Approximately 40% of the total population in the European Union is reported to live in coastal regions (Eurostat, 2013). In Norway, which has 5.4 million inhabitants, 82% of the population is reported to live within 15 km of the sea (Eurostat, 2013). Coastal areas and marine ecosystems are vital sources of prosperity for humans via jobs, economic activity, goods and services (European Commission, 2017).

Since the latter decades of the 20th century, many small-scale fisheries worldwide have decreased or disappeared. Collapses in fisheries have largely been attributed to the effects of overfishing, climate change and neoliberal policy shifts in fishing (Fleming et al., 2019; Pinkerton & Davis, 2015). The decline in small-scale fishing is especially apparent in Norwegian rural coastal areas. Fish stocks have plummeted, new aquatic regulations have been imposed, the number of fishers and vessels have decreased substantially and the remaining fishing fleet has undergone significant technological developments. Therefore, many Norwegian fishery-dependent coastal communities have undergone a considerable restructuring of their local labour markets following the loss of a local industry.

The overall health of a population can be closely connected with societal changes. The observed restructuring of many Norwegian coastal labour markets can be considered a natural experiment at the population level and is therefore of great interest for social-epidemiological studies (Diez-Roux, 1998). Despite an increasing interest in the health of coastal populations over the past decade, limited studies involve health in coastal communities that have a long-standing reliance on fishing. Existing research regarding coastal health does not focus on the heterogeneity within coastal settlements, thus providing limited evidence of how traditional fishery-based coastal communities fare in health compared with other coastal or inland areas.

This thesis examines the health situation and health trends in a Norwegian rural coastal population following the decline in small-scale fishing and the general restructuring of its local labour market. The data utilised in this dissertation were collected through the Trøndelag Health Study (The HUNT Study) in a Norwegian county with both coastal and inland settlements. Data were collected over four decades, providing the opportunity to assess decennial developments in population health. In this thesis, generational and educational health inequalities are studied across four decades in this rural coastal population, and findings are compared with adjacent areas in the county to assess geographical disparities over time. Essentially, the aim of this thesis is to provide further knowledge regarding population health developments during and after labour market restructuring.

This study is part of the NTNU Oceans research programme, ‘Norway as a Sea Nation: Coastal communities, generations, sustainability’. This inter-faculty research programme aims to establish a deeper knowledge base of the dynamic interplay between education, identity and society across three generations in coastal communities in five countries (NTNU, n.d.). Research teams from four NTNU faculties are included, among them Faculty of Medicine and Health Sciences.

2 Background

In this chapter, I provide background and context to the aims of this study and the interpretations of findings. The sizeable amount of existing literature and theoretical framework for interpreting developments in coastal health suggest that this chapter should not be considered an exhaustive overview of relevant literature. First, I introduce a general theory of health in restructuring societies presented by Aase (1993). Second, I outline a general overview of key developments in Norwegian coastal communities. Third, I provide selected literature on geographical health disparities, coastal health and social health inequalities. In combination, this overview provides knowledge of the actual developments in the thesis' study area and relevant perspectives for interpreting trends in this population's health status.

2.1 Restructuring of societies and its effects on population health

The main topic of this thesis is restructuring and its potential intertwinement with the population's health. Although many consider health and illness to be personal and individual, changes in one's health status can be closely connected to changes in one's societal and environmental contexts (Bury, 1997). Such changes may occur in the physical context—such as pollution, climate changes and food availability—but changes can also be observed in greater social constructs, such as fluctuations in economies, industries, educational levels and welfare expenditures. In this thesis, I focus on adaptations in social constructs, which can be considered larger structural changes in societies that may transpire quickly or over time. In modern times, we can observe that health of populations has been affected more by social change operating over time than by short-term policy interventions (McKeown et al., 1972). When such changes transpire over time, societal restructuring entails that each new cohort of inhabitants are confronted with different social and economic conditions (Sund & Jørgensen, 2009).

Many Norwegian coastal areas have been characterised by a substantial social restructuring since the mid-20th century (a development which is elaborated upon in Chapter 2.2). Although few studies have been conducted regarding the health situation in these areas, population statistics have revealed health to be generally poorer in coastal areas compared with other areas, especially in Northern Norway (Aase, 1993, 1996). Aase (1993) discusses this tendency in light of societal restructuring and outlines three perspectives from which population health can be viewed: intervention, diffusion and restructuring. These perspectives are presented in the following paragraphs; however, considering the purpose of this thesis, restructuring receives the main emphasis.

The perspective of *intervention* emphasises the measures of intervention introduced to improve public health (Glanz et al., 2008). This includes both preventive and health-promoting measures, and the effects of these measures are often evaluated by assessing the development in incidence of disease or mortality following the intervention. Preferably, one also evaluates developments in a control group, such as a population from an area not affected by the intervention. Such evaluations are challenging, and results are often debated. Additionally, these types of evaluations often indicate that the control group also exhibit changes in health-related behaviour; hence, it can be difficult to isolate the effect of an intervention from other societal developments (Aase, 1993). This brings us to the following perspectives.

Diffusion describes how new ideas and technology spread in a social system (Rogers, 2003). Innovations, in this instance related to health, are often adopted at different rates by different groups in the social system. For example, variations in adoption rates are found both on social and geographic scales. New lifestyle habits and health innovations are adopted first in groups with high socioeconomic positions, whereas groups with lower socioeconomic positions follow later. One can therefore often observe that shifts in illness incidence occur with some delay according to socioeconomic position (Aase, 1992). The same delay is evident in the geographical sphere, where one can observe that new lifestyle habits and health innovations often spread from urban to peripheral areas (Aase, 1993). Diffusion models have, to some extent, been dismissed as relevant in explaining geographical disparities in health. As the general speed of information flow is increasing, the importance of geographical affiliation is weakening (Sund & Jørgensen, 2009). Moreover, the diffusion perspective often assumes that other societal characteristics are constant, which Aase (1993), in his analyses of Northern Norwegian health developments, finds to be an untenable assumption. A society may have undergone significant changes during the period of adopting new lifestyle habits, which brings us to the perspective of restructuring.

Health changes in a population normally occur over long periods, which weakens the diffusion perspective (Aase, 1992). Structural changes in a society can affect the health of its inhabitants. New birth cohorts are confronted with different health risks than their predecessors, which emphasises the importance of *restructuring* in a population’s health status. Such reorganisation can comprise a wide variety of societal changes and includes transformations in work sectors, education, physical environments, moving patterns and lifestyle habits, among others. Aase (1993) introduces a pair of concepts for interpreting health developments during restructuring: *positional* effects and *structural* effects.

Positional effects are improvements in health within a specific group. For example, improved health in an occupational group due to safer working conditions can be considered a positional effect. Positional effects can occur on their own, but they may also be further reinforced by structural effects. Structural effects are health changes produced by shifts in a population's composition. Larger processes of change in a society, over time, influence the number of people living with different types of risk exposure (Aase, 1992). For example, urbanisation affects the number of people living with risks connected to the degree of urbanity; similarly, surges in higher education affect the number of people who attain a degree and are subsequently more likely being more receptive to health information; and industry restructuring affects the number of people in specific occupations and associated potential health hazards. Essentially, if a population group with fewer health hazards increase while a group with increased health hazards decline, then the overall health in a population improves (Aase, 1993). Combined with positional effects, one can, for example, observe that the overall health improves for a specific group at the same time as the group, due to structural changes, also increases in size. This results in an overall larger improvement of the population's health (Sund & Jørgensen, 2009; Aase, 1993).

The perspectives of intervention, diffusion and restructuring can, to some extent, be intertwined, and Aase (1993) emphasises the challenge of isolating these processes from each other in epidemiological studies that assess potential causes for change in a population's health. Moreover, other factors, such as migration, are useful when assessing changes in a population's health over time. Geographical mobility may be an important agent behind geographical disparities in health (Bentham, 1988), as selective migrants overall are found to exhibit better health (Riva et al., 2011). Selective migration can induce shifts in a population's composition and can therefore, in many cases, be considered a process of restructuring. In this thesis, where I assess health trends against the backdrop of larger shifts in the coastal labour market, special emphasis will be given to the perspective of restructuring in the interpretation of results.

2.2 Restructuring fishing communities: The Norwegian context

In this thesis, data from a Norwegian coastal population is used to examine health trend developments during and following societal restructuring. In this section, I provide an overview of the main developments in rural Norwegian coastal communities after the mid-20th century, focussing on the significant restructuring of coastal-related occupations, changes in everyday life in coastal communities and larger demographic shifts that affect rural coastal communities. These restructuring processes relate to changes in work status as well as life, educational levels and demographic composition; therefore, they are, both separately and combined, associated with changes in the population's health. This is a brief summary of several extensive developments. Some topics, such as oil and gas, gender perspectives on coastal living and the reliance upon foreign labour, are mentioned but not elaborated on further. Other topics, such as developments in coastal infrastructure, are not included in this overview.

A significant portion of this chapter is based on Norwegian literature that describes the restructuring in Norwegian coastal communities. Some international references are included to provide a connection to general topics regarding coastal settlements and coastal-related industries.

2.2.1 Life in Norwegian coastal communities

Norway is a sea nation with a long-standing involvement in and reliance upon ocean resources for employment, economic activity and coastal settlements (Sønvisen et al., 2011). Historically, Norwegian coastal communities, which are typically rural and sometimes remote, have been characterised by the interplay between fisheries, the fishing industry, the service industry, households, and schooling (Jentoft, 2020; Vik et al., 2011). Jentoft and Wadel (1984) describe these factors as crucial components of the *coastal employment system*, as these elements were dependent upon each other in sustaining and securing employment within coastal communities. Contrary to other industries in modern society, which are characterised by formal contracts and market mechanisms, the coastal employment system is depicted as more informal and dependent upon social relations and mutual reliance between actors (Jentoft & Wadel, 1984; Sønvisen et al., 2011).

In Norway, fishing has historically been performed on a small scale, with a fishing fleet primarily comprised of smaller vessels. Fishing has traditionally been tied to the local community and has been based on a simple and direct relationship between fish and fisher (Jentoft & Wadel, 1984; Sønvisen, 2014). For many, fishing was combined with agriculture to secure full-time employment. This entailed seasonal shifts in working priorities and whole-household involvement, where women had responsibilities in fishing and farming in addition to domestic tasks, ranging from handling the fish after landing to childcare (Jentoft, 2020; Jentoft & Wadel, 1984).

Fishing was a lifelong occupation in which recruitment of men into the local fishing fleet typically occurred at a young age; boys were socialised into a collective of shared knowledge, ideas, values, symbols and culture (Johnsen, 2004; Vik et al., 2011). This socialisation into the coastal employment system took place as a part of daily fishing activities within the household and community and did traditionally not require any formal education (Hetland, 1984; Vik et al., 2011). Childhood narratives from current elderly Norwegian coastal inhabitants reveal that a transferring of knowledge between generations was a crucial part of being socialised into and belonging to a traditional fishing society (Kjørholt & Bunting, 2021). Furthermore, entrance to the fishing occupation did historically rely heavily on vessels belonging to family and friends (Sønvisen et al., 2011).

The life of a small-scale fisher has historically been characterised by risk and hardship (Koren, 2017). Fishing is generally considered to be a hazardous occupation with long hours, extreme weather and risk of injuries (Broch, 2020; Matheson et al., 2001; Petursdottir et al., 2001; Thorvaldsen, 2015). Life onboard smaller vessels with a small crew entailed challenging and risky fishing combined with increased vulnerability to weather conditions (Johnsen, 2005). Mortality reports in the Norwegian fishing fleet reveal that the majority of fatalities were fishermen in small vessels, many of whom worked alone (Christiansen & Hovmand, 2017). Fishers have also been found to report more musculoskeletal problems than the average population (Sandsund et al., 2019). Additionally, the lifestyle among fishers has been associated with higher levels of both smoking and alcohol intake (Koren, 2017; Thorvaldsen et al., 2016).

Although coastal communities vary in factors such as size, location, remoteness and alternative employment sectors, small-scale fishing and its ties to the communities have generally been prominent in Norwegian coastal societies. Therefore, the decline in small-scale fishing taking place from the 1950s is of utmost interest when studying the health of rural coastal populations.

The following subsection describes the decline in small-scale fishing as well as other key societal developments in coastal areas.

2.2.2 The decline in small-scale fishing: Technological developments, stock collapses and neoliberal shifts in coastal management

Since the latter decades of the 20th century, many small-scale fisheries worldwide have decreased operations or disappeared. This international trend is attributed to a combination of factors, such as over-fishing, pollution, habitat destruction, ocean acidification, rising sea surface temperatures, loss of species from food webs and other physiochemical and biological changes in the oceans (Fleming et al., 2019; Food and Agricultural Organization of the United Nations, 2018) Concurrent with these environmental developments, the quota regulations following international neoliberal policy shifts in fishing have increased pressure on small-scale fishers worldwide (Fleming et al., 2019; Pinkerton & Davis, 2015).

The decline in small-scale fishing is also apparent in Norway. From 1945 to 2010, the number of fishers dropped to one-sixth of the original number as the landings per fisher increased twentyfold (Giskeødegård, 2014)—the number of remaining vessels decreased and the vessels increased in size (Johnsen, 2005). This reduction in small-scale fishing is, to a large extent, attributable to the combination of several factors: stock collapses, new aquatic regulations and technological developments in fishing gear and vessels.

Norwegian fishing communities experienced several substantial collapses in fish stocks in the later decades of the past century (Christensen, 2014). In short, the combination of lacking regulations and developments in catching technology in the 1960s laid the foundation for prolonged overfishing. In the late 1960s, the stocks of spring-spawning herring collapsed (Bjørndal et al., 2004), an incident which repeated itself with coastal cod in the late 1980s (NOU 2008: 5).

Following these collapses in fish stocks, Norway was part of the international neoliberal shifts in coastal management. Since the 1980s, this general shift in Western countries has entailed a growing emphasis on private property rights, economic efficiency, government cutbacks and devolution of responsibilities and risk to the private sector. This development has affected fisheries worldwide, as the perception of overfishing and economic inefficacy have been used as justification for reducing the number of small-scale fishing enterprises (Pinkerton & Davis, 2015). The emerging trend of privatisation in fisheries management has been characterised as pitting economic efficiency against culture and community, and many believe that regulating quotas and licenses has played an inevitable part in the substantial decrease of small-scale fishers (Maurstad, 2000; Olson, 2011). In Norway, the coastal fleet was previously characterized by open access without quota restrictions (Standal et al., 2016). After the 1980s' cod crisis, new quota regulations were introduced in 1990 to secure sustainable resource usage (Trondsen & Ørebech, 2012). The new regulations were perceived to affect fishers unjustly, where the size of allocated individual vessel quotas did not necessarily correspond to the vessels' expected catches. This created strong incentives to adapt, and the vessel types in the coastal fleet were replaced to fully utilise catching potentials within the new regulations (Standal et al., 2016).

A gender perspective also emerged with the quota regulations (Gerrard, 2008). Some have argued that the quota regulation, by favouring professional, full-time fishers, not only excluded part-time small-scale fishers but also generally excluded women from fishing, as they often had additional household duties that were incompatible with a full-time occupation in fishing (Munk-Madsen, 1998).

In addition to stock collapses and new quota regulations, the Norwegian fishing fleet has undergone a substantial technological development. Overall, modern fishing vessels are larger, more powerful and more technologically sophisticated (Johnsen, 2005). The implementation of catching equipment, such as power blocks and sonars, benefitted purse seine vessels by substantially increasing harvest efficiency (Bjørndal & Gordon, 2000). Despite the significant reduction in the number of people involved in fishing, the capture capacity of the Norwegian fishing fleet has increased, often exceeding available resources (Johnsen, 2005; NOU 2006: 16; Vik et al., 2011). The fishing occupation has undergone specialisation, and the need for specialised skills has inhibited mobility between vessels and economic sectors, making fishing the sole occupation for the majority of fishers (Sønvisen et al., 2011). Formal education has become important, where larger and more technologically complicated vessels are found to value formal education more compared with other vessels, although experience remains a priority regardless of vessel size (Sønvisen et al., 2011). Additionally, the fishing occupation has become safer, as it now likely poses fewer health hazards to workers. Technological developments in the fishing fleet have reduced the physical workload on board, improving the overall labour situation for Norwegian fishers (Johnsen & Vik, 2013). Furthermore, an increasing number of safety measures have been introduced in governmental risk management for the Norwegian fishing fleet (Thorvaldsen, 2015). Reports from the Norwegian fishing fleet indicate that fishing now involves a lower risk of injuries and fatalities than previously (McGuinness et al., 2013a, 2013b).

In short, the current Norwegian fishing fleet is a testimony to the larger processes that occurred following the mid-20th century. The demand for manpower in fisheries has decreased with the increased productivity and technological developments, while the demand for manpower has increased in other growing sectors of the labour market (NOU 2006: 16). Fishing now provides employment for fewer people, the average age of fishers is increasing, and recruitment is based on larger geographical areas (Sønvisen et al., 2011). These factors must be seen in light of the emergence of new coastal industries, which are described in the following section.

2.2.3 New utilisation of coastal resources

Internationally, the utilisation of marine resources is expanding rapidly: marine economies now encompass coastal and ocean activities related to fishing, aquaculture, transportation, marine energy, tourism and oil and gas (Morrissey, 2017). This is also apparent in Norway, where coastal areas and resources continue to be crucial parts of today's economy. Since the 1960s, Norway has experienced tremendous developments in marine exploitation. Fishing, although on a larger scale, remains a significant and extensive Norwegian coastal industry. The current fishing fleet, now comprised of larger vessels, targets cod, herring, mackerel and other whitefish as well as small pelagic species (Food and Agricultural Organization of the United Nations, 2018). Coastal areas are also important regions for the oil and gas industry. Since the first oil discovery in Norway in 1969, this industry has provided a substantial national income in addition to considerable growth in innovation and employment in several coastal regions, primarily on the southwest coast (Christensen & Zachariassen, 2014).

In recent decades, an important, emerging Norwegian coastal industry has been fish farming. In addition to the substantial technological developments and upscaling of the fishing fleet, Norway has exhibited a noteworthy advancement in fish farming since the industry's emergence in the 1980s. Globally, aquaculture (including aquatic plants) is growing faster than other major food production sectors; between 1990–2020, the total world aquaculture production expanded by 609 percent (Food and Agricultural Organization of the United Nations, 2022). Norway has established an extensive salmonid aquaculture sector, and in 2020, the nation was the second-largest exporter of fish and fish products worldwide, beaten only by China (Food and Agricultural Organization of the United Nations, 2022).

Investments in Norwegian fish farming were initially modest. The collapse of the spring-spawning herring in the late 1960s prompted many fishers to re-evaluate the possibilities in fishing, and aquaculture presented itself as an opportunity (Christensen & Zachariassen, 2014). Fish farming transitioned from fresh water to seawater, and trout was replaced with salmon as the leading farmed fish (Christensen & Zachariassen, 2014; Steinset, 2017). The transition was gradual, as fish farming initially constituted only an additional source of income for many fishing companies and fishing families. Eventually, fish farming largely became a full-time occupation, and many transitioned from traditional fishing (Christensen & Zachariassen, 2014). The fishing industry and fish farming have since coexisted, although disputes have emerged regarding access to coastal areas following the fish farming expansion in the mid-1980s (Christensen & Zachariassen, 2014).

Today, Norwegian fish farming is growing rapidly and offers a substantial export value. In 2020, Norway sold farmed salmon and trout for over US$7 billion (Fiskeridirektoratet, 2021). The majority of production occurs within the 10 largest companies, which have substantially higher operating margins than the traditional fishing industry (Steinset, 2017). The emergence of fish farming has provided new employment opportunities in the coastal sector. In 2020, around 9,000 people were employed in Norwegian aquaculture (Fiskeridirektoratet, 2022). More widely, aquaculture has had a ripple effect in both employment opportunities and economic activity in a wide range of associated sectors through the need for equipment, fish feed and technical services (Richardsen et al., 2019). Norway's leading fish-farming county is Trøndelag. From 2010 to 2018, the county exhibited a 70% growth in farmed food fish production, and 325,000 tonnes were produced in 2018 alone (Sliper, 2019). In Trøndelag, Hitra and Frøya municipalities are prominent on a national level as farmed fish producers; additionally, Nærøysund municipality (formerly Vikna and Nærøy) has a somewhat smaller but still noteworthy aquaculture sector (Trøndelag Fylkeskommune, 2018).

2.2.4 Processes of restructuring in Norwegian coastal communities

The substantial restructuring of the fishing industry, as described previously, has been accompanied by a larger restructuring of many Norwegian coastal societies. This restructuring was comprised partly of the aftermath of the decline in small-scale fishing and partly of larger national developments in Norwegian society. The decrease in small-scale fishing, which was instigated by technological developments, stock collapses and new regulations, predominantly caused a loss of livelihoods and employment opportunities for the majority of people working in fishing. As fishers often were sole providers for their families, whole families were potentially afflicted by this decline in small-scale fishing. On a larger scale, the close ties within the coastal employment system (Jentoft & Wadel, 1984) resulted in larger parts of coastal communities being affected by the downturn. Since the mid-20th century, the declines in small-scale fishing have been accompanied by other prevailing demographic changes and extensive investments in the Norwegian public sector. In the following, developments in migration, education and public sector employment are briefly outlined.

2.2.4.1 Outmigration and urbanisation

The detrimental decline in small-scale fishing was entangled with demographic changes and moving patterns in Norway at the time. The rapid decrease in small-scale fishing was one of several driving forces for the substantial outmigration from Norwegian rural coastal areas (Hundstad, 2014; Johnsen, 2004). In general, Norwegian rural areas faced a rapid outmigration in the decades following World War II (Hundstad, 2014; NOU 2020: 15). Population statistics from rural coastal municipalities in the 1970s and 1980s describe increasing outmigration during these decades, despite overall population growth in Norway (Sørlie, 1990). This trend persisted through the 1990s, although variations occurred across coastal municipalities (Myklebust, 2001). The corresponding national wave of urbanisation at the time remains unmatched in a Norwegian context, leaving many coastal communities largely or completely abandoned (Sognnes, 2015). Communities without mainland connections were especially afflicted, as daily commuting to adjacent areas was not an option for inhabitants (Hundstad, 2014).

During the wave of urbanisation, there existed a general national aspiration of gathering the coastal communities into larger towns, as coastal inhabitants traditionally lived widely dispersed along the coastline (Hundstad, 2014). Influenced by the developments in the fishing fleet, the perception of what constituted a peripheral coastal community had changed: the former necessity of being localised far out on the coast was replaced with the greater flexibility and mobility of the new fishing fleet; hence, adequate harbour conditions became essential (Hundstad, 2014). In other words, the shift from small-scale fishing to larger and technologically sophisticated fishing vessels altered the necessity and incentive to maintain the existing level of inhabitation in many Norwegian rural coastal areas.

2.2.4.2 The formalisation of education and socialisation

Thus far, this chapter has described the declining recruitment into fishing as a consequence of fewer opportunities for employment in a disappearing industry. Nonetheless, as mentioned, specialising the fishing occupation has generated an increased need for formal education for fishers (Sønvisen et al., 2011). This development is part of a general trend toward education formalisation and secondary socialisation, although the change is apparent in an industry that formerly relied heavily on the transferring of knowledge between generations in its recruitment. Throughout the 1970s and 1980s, the long-standing primary socialisation into fishing from a young age, which involved first-hand exposure to fishing through one's household, was increasingly replaced by a formal school system with education that extended beyond primary education (Sønvisen et al., 2011; Vik et al., 2011). Generally, industries exhibited increasing demands for formal qualifications. Consequently, local schools became increasingly oriented toward the needs of the national labour market rather than being part of a local employment system (Johnsen, 2004; Vik et al., 2011). Today, the majority of young Norwegians finish secondary education (Udir, 2021).

With the growing demand for formal education, the notion and perception of life courses for rural coastal youths have changed. This has been further reinforced by increasing globalisation. In the latter half of the past century, Norwegian youths were becoming increasingly oriented toward global and non-local references, potentially weakening local cultural influence, identity and arenas for interaction (Øia et al., 2001). Accordant with national trends of urbanisation and selective migration, rural youths have expressed the urge to relocate to more densely populated areas, which is often justified by the need for education, relevant employment and self-realisation (Broch, 2022; Wiborg, 2000). Education and alternative employment opportunities have been described as potential *pull factors*—pulling coastal youth away from an insecure future in the fishing industry (Johnsen & Vik, 2013). The general trend toward formalisation and globalisation of education has therefore been an important part of the reduced recruitment into fishing; however, it has also established new life courses for young coastal inhabitants. Considering that educational level is a well-established determinant of health (see Chapter 2.3), formalisation of education could potentially be intertwined with health trends in coastal populations.

2.2.4.3 The expansion of the Norwegian public sector

Despite its depiction as a time of outmigration and loss of livelihoods, the period following the mid-20th century was, in many Norwegian rural coastal areas, characterised by growth in other sectors. The emergence of fish farming has been described. Perhaps most importantly, Norway has experienced significant growth in its public sector. The post-war era was a time of tremendous investments in the Norwegian public sector; 80% of the national net increase in man-years between 1950 and 1980 occurred in public service production, with a substantial proportion of the increase in education, health and social services (Mørk, 1984). From 1970, public sector employment growth increased still further, with an average yearly increase of 13,500 man-years between 1970 and 1980 (Mørk, 1984). The public sector provided employment in many educational categories and to groups with traditionally weak positions in the local labour market (Mørk, 1984). Women especially benefitted from these national investments in public sector and have explosively entered the labour market since the 1970s (Ellingsæter et al., 2020; SSB, 2019a). Additionally, the growing investments in public sector entailed more than employment opportunities: the development was, in many ways, part of a greater expansion of public services and a strengthening of welfare schemes and benefits (Ellingsæter et al., 2020; Mørk, 1984).

The effects of public sector strengthening were also apparent in rural coastal areas. The trend of outmigration from coastal areas increased after World War II and were especially apparent in the 1970s and 1980s (Sørlie, 1990). During the 1970s, national public investments were characterised by an active policy to maintain settlements in peripheral areas. Peripheral areas were increasingly perceived as valuable, and settlement patterns were becoming established (Brox, 1980; Johnsen, 2004; Aasbrenn, 1984). Norwegian rural areas that had been dominated by primary industries and traditional refining industries became communities with large public sectors. Public services were in the 1980s described as the most important rural industries of the time (Aasbrenn, 1984). Rural areas, also coastal, became increasingly dependent upon national investments and welfare schemes and have been characterised as areas of limited innovation in business and societal developments (Aarsæther & Nyseth, 2007). Therefore, the extensive national public sector investments were paramount to coastal labour markets that were experiencing the loss of a long-standing industry. These investments were especially beneficial for coastal women, who were increasingly finding employment in the tertiary sector and therefor had limited opportunities to contribute as a reserve labour source in the fishing industry (Johnsen, 2004; Tjelmeland, 1994; Vik et al., 2011).

2.2.5 Norwegian coastal communities today

To summarise, many Norwegian rural coastal communities have experienced significant societal restructuring since the implementation of quota regulations, technological developments in fishing and fish farming. These processes have been accompanied by and often entangled with greater national developments in demography and the public sector. It should be emphasised that the restructuring of Norwegian coastal communities has not been a uniform process that affected societies equally across coastal regions and settlements; however, the decline in small-scale fishing has undoubtably entailed a substantial restructuring of the majority of coastal communities. In rural coastal areas, fishing is now a smaller part of the local coastal economy and employment system, and ties between the community and the fishing industry have been weakened (Johnsen, 2004). Nevertheless, current vessel owners have been found to report few problems with recruiting crew, where primary socialisation remains an important channel into the fisheries (Sønvisen et al., 2011). The orientation toward the local community continues to be strong among agents connected to smaller fishing vessels in Norway (Vik et al., 2011).

Some communities have dissolved in the face of the decline in small-scale fishing and urbanisation. This is apparent across current Norwegian coastlines, where especially the remotest fishing villages—often small clusters of buildings located on islands—are vacant and perhaps used as summer cabins (Flognfeldt, 2002). Other coastal communities have survived, although the with a trend toward inhabitants moving to municipality centres (Brox, 1980).

Overall, national developments in the educational system, the public sector, welfare schemes, as well as developments in infrastructure and digitalisation have culminated in rural coastal areas that now provide services and life courses for inhabitants that are similar to other geographical areas (Broch, 2022; Aarsæther & Nyseth, 2007). Compared to fishing, which entails variable working hours, periods away from home and a fluctuating income, other occupations are now considered more attractive by most coastal inhabitants (Johnsen et al., 2013). Nonetheless, employment and educational opportunities in rural coastal areas, as in rural areas overall, are somewhat limited, which has resulted in selective migration among young people (Broch, 2022). Some choose to return to the rural coast to start their families (Kjørholt & Bunting, 2021), and some coastal communities have experienced population growth, although the overall Norwegian trend is outmigration from rural and coastal areas (Iversen et al., 2020; Johansen & Onsager, 2017).

Regarding utilisation of marine resources, the current Norwegian coastal areas are characterised by diversity. As stated previously, fishing is now an occupation for fewer residents, and new coastal industries have emerged. On Norway's southwest coast, the decline in small-scale fishing has been followed by a flourishing oil and gas industry (Christensen & Zachariassen, 2014). In Central Norway, from where the study population in this thesis were derived, aquaculture has established itself as an influential industry (Trøndelag Fylkeskommune, 2018). In Northern Norway, many large landing stations remain highly active (Riksrevisjonen, 2020). Nevertheless, recruitment into fishing and aquaculture is challenging, and the majority of Norwegian coastal industries today are partially or highly dependent upon foreign labour (Rye, 2018; Tiller et al., 2015).

In short, Norwegian coastal communities have undergone a great transformation since the mid-20th century. From a social-epidemiological perspective, and for the purpose of this thesis, developments related to changes in work status, life and demographics have been outlined in this chapter. In the interpretation of our findings, this backdrop provides a historical corroboration to the literature regarding coastal health and geographical- and social inequalities in health, which are presented in the following.

2.3 Geographical inequalities in health: Existing literature and concepts

Considering the purpose of this thesis, spatial perspectives on health are fruitful when comparing health variations across the different geographical areas in which our study population resides. Poor health is not equally distributed throughout populations; the prevalence of and exposure to risk factors differ across neighbourhoods, cities, regions and nations (Gatrell & Elliott, 2014). The causes of geographic inequalities in health are complex and not fully known. Possible explanations for spatial health variations have been presented and studied extensively. In the following, I first present a brief overview of existing research on coastal health. Second, I present two key concepts in the literature regarding geographical inequalities in health: context and composition and the rural-urban distinction in spatial health variations.

2.3.1 Coastal health: A brief review of existing research

Population statistics have revealed that coastal populations exhibit poorer health than other populations. According to the Office for National Statistics, the coastal populations of England and Wales are more likely to report poor health than inland populations (Office for National Statistics, 2014). In Norway, national health atlases have reported poorer health and increased mortality in several coastal populations than in similar groups who live further inland (Aase, 1996).

In recent decades, interest has increased in the health of coastal populations. Being populations of substantial size and diffusion, unique in their proximity to marine surroundings, the coastal populations comprise a group of great research interest regarding the assessment of spatial and environmental aspects of health. In the following subsections, I describe some main research fields concerning health in coastal populations. The research field of coastal health is large and diverse, with a wide range of studies covering different perspectives on health and the sea; hence, this section offers only a superficial overview of existing literature. The purpose of this overview is to present a glance at the main research questions of interest in coastal health, which can essentially be divided in two: the potential direct health effects of observable coastal pathogens and climates and the potential indirect health effects of factors connected to living in coastal surroundings. Based on this summary, I briefly discuss the existing literature's underlying methodological premises of the leading definition of coastal populations.

2.3.1.1 Health and coastal proximity: Coastal environments and blue spaces

Numerous studies have assessed the impact of coastal surroundings on health – approaching the subject from various perspectives. The coastal environment can pose a direct hazard to inhabitants through death and morbidity connected to flooding following sea level rise and storm surges as well as through hazardous marine occupations (Depledge, 2018; Fleming et al., 2019). A majority of existing studies shed light on the association between health and the specific environmental and biological traits of coastal surroundings. As the oceans provide a source of food, the potential pathogens of seafood have been studied intensively. Although seafood is generally considered to be a beneficial dietary addition (Fleming et al., 2019), seafood-borne diseases are a substantial hazard to public health worldwide through several aetiological agents (Elbashir et al., 2018). In Norway, however, as one of the world's largest exporters of seafood, the level of undesirable substances in fish is generally low, and the positive impact of fish consumption is believed to outweigh the health risks of current contaminant levels and other known undesirable substances in seafood (Andersen et al., 2022). Relatedly, coastal water quality has been of great research interest. Oceans and estuarine ecosystems may impact the extent to which humans are exposed to disease-causing organisms. Pollution and contamination of coastal water, through, for example, oil, heavy metals and algal blooms, can pose substantial health risks for those reliant upon marine ecosystems worldwide (Bierman et al., 2011; Fleming et al., 2019). New detection methods for microbial pathogens have been developed and tested, in which idiosyncrasies of different geographical areas, such as climate, are taken into account (Stewart et al., 2008). By extension, intensive research has enhanced understanding of the relationship between coastal and marine environments and human health (Stewart et al., 2008).

In addition to the comprehensive research on coastal pathogens, some studies have assessed coastal living's general contributions to human health. Long-standing perceptions present coastal areas as contributors to human health and well-being; these regions have historically been considered beneficial scenery for convalescence (Fox & Lloyd, 1938). Following previous findings of the potentially positive health effects of greenspaces (Mitchell & Popham, 2008; Richardson et al., 2013; Van den Berg et al., 2015), the potential health benefits of living near blue spaces have been examined. Recent studies offer growing evidence of the potential public health benefits of both individuals and communities' interactions with the surrounding sea and oceans (Fleming et al., 2019). Wheeler et al. (2012) find gradual increases in self-reported good health with proximity to the coast in England, adjusted for age, sex, greenspace density and socio-economic confounders. This positive health gradient is strengthened with increasing socio-economic deprivation, which suggests mitigating effects of living near the coast on the negative health effects of socio-economic deprivation (Wheeler et al., 2012). This positive association between coastal proximity and health is further supported by a longitudinal panel study in which individuals reported significantly better general and mental health when living nearer the coast; this study also controlled for both individual and area level factors (White et al., 2013).

Higher levels of physical activity have been suggested as an explanation for the association between coastal living and good health, which implies that physical movement is encouraged in coastal areas (White et al., 2016). White et al. (2014) present a small but significant coastal proximity gradient for the likelihood of achieving recommended guidelines for physical activity in England, adjusted for relevant area- and individual-level covariates. Nonetheless, effects varied between coastal regions. Pasanen et al. (2019) assessed the potentially mediating role of both water- and land-based activities. They find that living nearer the coast is associated with better self-reported general and mental health, although they indicate that the amount of on-land outdoor recreational activity, as opposed to water sports, mediated the relationships between coastal proximity and both general and mental health.

The mere proximity of coastal surroundings is also suggested to positively affect the mental health of coastal inhabitants. Garrett et al. (2019) demonstrate that urban English adults who live 0–1 km from the coast have significantly lower odds of common mental disorders than those living further than 50 km from the coast, after adjusting for both individual- and area-level covariates. This association is strongest among more deprived groups. In older Irish adults, the mere view of coastal blue spaces is associated with reduced risk of depression, after adjusting for both individual-level covariates and population density (Dempsey et al., 2018). This finding is supported by a study of urban adults in New Zealand in which increased visibility of blue space is associated with lower psychological distress, after controlling for covariates (Nutsford et al., 2016).

2.3.1.2 The leading definition of coastal populations: An emphasis on coastal proximity

When reviewing existing research on coastal health, the importance of closeness to the sea is apparent. Despite the wide range of both exposures and health outcomes in existing literature, the definition of coastal populations is primarily based solely on proximity to the coastline. This definition provides opportunities to assess geographical health disparities through either a coastal gradient in which people’s proximity to the sea is compared or through a clear cut-off, which provides a straightforward distinction between coastal and non-coastal areas and inhabitants. This perception of coastal areas and populations, based on physical proximity to the coast, is useful when the coast itself or closeness to the coast is believed to affect the health of nearby inhabitants. A straightforward coastal or non-coastal classification can therefore be a valuable methodological tool in epidemiological studies that assess the contextual aspects of health inequalities associated with coastal living.

Nevertheless, coastal regions are characterised by great heterogeneity both in population density and composition as well as in engagement with the surrounding coast. The leading definition of coastal populations and areas provided in this overview indicates that existing research on coastal health has, to a limited extent, captured the heterogeneity within coastal regions. An example of such heterogeneity is the rural-urban dimension, which is presented in Chapter 2.3.3. Despite sharing the trait of coastal proximity, the health situations are likely to vary between urban areas that are near the coastline and rural coastal communities with long-standing dependence on coastal resources. In this review of the literature on coastal health, I identify a lack of studies that differentiate between different coastal populations when assessing health. Therefore, to my knowledge, the current research field on coastal health is limited in capturing specific traits and heterogeneity of specific areas. This emphasises the need for further exploration of these variations in coastal health, which is one of the main methodological purposes of this thesis. Spatial variations in health can depend on factors other than coastline proximity, and therefore some key perspectives from the literature on geographical health disparities are of interest.

2.3.2 Context and composition

One key aim in many studies of geographical health disparities is to distinguish between *contextual* and *compositional* effects on health (Curtis & Rees Jones, 1998; Subramanian et al., 2003). Contextual effects refer to the influence of higher-level units on health. Group properties and macro-level variables can affect health outcomes independently of individual characteristics (Diez-Roux, 1998). In other words, processes that influence individual health may operate differently from place to place (Curtis & Rees Jones, 1998). Contextual factors include neighbourhood characteristics, distance and availability of health services and facilities, degree of rurality, the presence of polluting factories and the absence of leisure activities. Contextual factors also include the social context in a geographical space, such as the sense of belonging, crime statistics and the general fear of crime (Shaw et al., 2002). Contextual factors are often tightly entangled with policies, infrastructural resources, and public support programs and are therefore considered to be relevant targets for interventions aiming to reduce health inequalities (Arcaya et al., 2015). A purely contextual interpretation of geographic health variations is vulnerable to the problems associated with the ecological fallacy in which the usage of aggregated population data conceals variations between individuals, leading to inaccurate assumptions about health at an individual level (Boslaugh, 2007).

Compositional effects are related to the varying distribution of individual traits in populations (Macintyre et al., 2002). Such individual traits that influence health include age, gender, smoking, diet and socioeconomic position. A purely compositional understanding of geographical health variations suggests that similar types of people have similar health experiences regardless of place of residence, which emphasises the hegemonic role of individual-level processes in population health (Curtis & Rees Jones, 1998). This interpretation is vulnerable to problems associated with the atomistic fallacy in which health effects from higher-level factors are overlooked or misinterpreted (Boslaugh, 2007).

When studying spatial variations in health, the contextual effects often appear to be clear explanations of observed health disparities (Shaw et al., 2002). Yet, it should be stressed that contextual effects often are mediated by and intertwined with the composition of the population, as many potential effects on health apply to both individual and structural levels (Diez-Roux, 1998; Macintyre et al., 2002; Shaw et al., 2002). Unemployment can be viewed as an individual trait; nevertheless, geographical areas can be characterised by varying levels of unemployment. Another example is poverty, which Smith (1977) posits can be both a trait of the area in question (place poverty) and of the individual (people poverty). Hence, the association between individual traits and health vary with the aggregated profile of the population (Curtis & Rees Jones, 1998). Macintyre et al. (2002) emphasise the importance of this dual relationship, advising caution when differentiating between contextual and compositional effects. Several studies have suggested that little geographical variance in health remains after controlling for compositional factors (Duncan et al., 1993; Fogelholm et al., 2006); however, describing context solely as a residual category may ignore the potential intertwinement between level effects (Macintyre et al., 2002).

2.3.3 The rural-urban dimension of health

As extensions of contextual effects on health, the differences in health between rural and urban areas have been studied extensively. Rural-urban health disparities are a worldwide phenomenon, although findings are mixed and vary between both health outcomes and populations. Studies from the US have found that rural populations fare worse than urban residents in several health measures (Eberhardt & Pamuk, 2004), including poor self-rated health, mortality, diabetes and coronary heart disease (Monnat & Pickett, 2011; O'Connor & Wellenius, 2012; Singh & Siahpush, 2014). Conversely, the rural population in the UK has been found to exhibit lower rates of both mortality (Gartner et al., 2008) and self-rated health (Riva et al., 2009) than their urban counterparts.

The Nordic welfare regime is built on universal access to health care and is therefore assumed to buffer against health inequalities, although studies in these countries have generally found less favourable health situations in rural areas compared to urban areas. In Finland, Norway and Sweden, mortality rates have been found to be consistently higher in less densely populated municipalities, with disparities increasing over time (Bremberg, 2020). In Norway, national statistics demonstrate that the reported prevalence of good self-rated health increases with population density, whereas long-standing illness decreases (SSB, 2019c). Moreover, rural populations have been found to exhibit less favourable cardiovascular risk factor profiles and higher rates of obesity compared to urban residents in Finland and Norway, respectively (Nuotio et al., 2020; SSB, 2019b).

It should be stressed that there is no definite methodological answer regarding where to draw the distinguishing line between rural and urban areas. When comparing the health situations of rural and urban areas, there exists a continuum along which health can vary (Eberhardt & Pamuk, 2004). Studies have found evidence of some health advantages for semi-rural areas compared to inner cities, while the remotest rural populations tend to exhibit relatively poor health (Curtis, 2004; Monnat & Pickett, 2011). Operating with a sharp distinction between rural and urban areas may therefore cover up small, localised pockets of rural deprivation. These deprivation hotspots may be of crucial importance to the local health situation, but their significance is often underestimated when working with area averages (Curtis, 2004). Moreover, some contextual effects may be more specific to either rural or urban areas; for example, the strength of the association between deprivation and health varies between rural and urban populations (Curtis, 2004; Curtis & Rees Jones, 1998).

Several explanations of the rural-urban health divide have been presented. Poor health in remote rural areas is suggested to be connected to contextual aspects, such as the isolation and lack of access to services and facilities that often characterise these areas and that may be crucial for good health (Bentham, 1984; Curtis, 2004). Differences in lifestyle risk factors are another possible explanation. Place of residence is not merely a physical context but also a social context in which cultural norms and perceptions about acceptable behaviour arise (Smyth, 2008). Therefore, local norms in smoking, alcohol and diet are potentially strong influences on inhabitants' lifestyle choices, especially in small and transparent rural communities (Elstad & Koløen, 2009). By extension, developments in lifestyle trends are assumed to originate in populations of higher socioeconomic status before they later reach people of lower socioeconomic status. Therefore, poor lifestyle habits in a declining phase, such as smoking, can reveal geographical inequalities in disfavour of rural areas (Elstad & Koløen, 2009). Divides in rural and urban health may also be explained by residential mobility. Studies from the UK have found that intra-national mobility partially explains spatial health inequalities, as selective migrants generally exhibit better health (Connolly et al., 2007; Riva et al., 2011). The likelihood of mortality of rural outmigrants is found to be significantly lower than that of long-term rural residents, which indicates a pattern of rural outmigration in healthier, younger adults in search of employment in urban areas (Riva et al., 2011). This could result in the remaining rural population exhibiting poorer health overall.

2.4 Social inequalities in health

In this thesis, perspectives on social inequalities in health are an important part of the theoretical framework, both regarding the study design and the discussion of findings. When studying trends in population health over time, the distribution of health between social groups is of utmost interest. In coastal communities characterised by labour market restructuring, some groups could be more vulnerable to changes and downturns. In the following subsections, I provide an overview of current data on social inequalities in health, their potential determinants, and the role of welfare states as buffers. Special emphasis is given to employment conditions and associated vulnerability to societal restructuring.

2.4.1 Existing knowledge on the social gradient in health

Good health is not distributed equally across populations or between different social groups within society. In developed countries, persistent health inequalities are found between socioeconomic positions, genders, ethnicities, social orientations and geographical locations, and these inequalities are generally viewed as unjust and avoidable (Bleich et al., 2012). The development of social epidemiology, a branch of epidemiology that focusses on the effects of social-structural factors on states of health, has caused an increase in the notion that the distribution of advantages and disadvantages in a society reflects the distribution of health and disease (Honjo, 2004). In this thesis, I focus on inequalities in health between socioeconomic groups.

A large bulk of the existing research on health disparities concerns socioeconomic resources or social class (Adler & Rehkopf, 2008). The breakthrough for modern research on social inequalities in health came with the publication of the *Black Report* by the British Department of Health and Social Security in 1980. This official state document outlines the substantial differences between occupational classes in mortality, morbidity and usage of health services, revealing a clear social gradient in the majority of the causes of death – in both genders (Bury, 1997; Macintyre, 1997). In the extensive literature on social inequalities in health published following the *Black Report*, this social gradient has been observed in both mortality and a wide range of health indicators in U.S. and European data (Braveman & Gottlieb, 2014). Marmot (2004) emphasises that the social gradient in health does not entail a clear health divide between the top and bottom of the social hierarchy, but rather a gradient where health improves as social position rises. Furthermore, the steepness of this social gradient in health varies both across countries and within countries in different time periods (Marmot, 2004).

Social health inequalities are widely studied and monitored in regions with available data—predominantly in Europe and North America—and the literature is constantly growing. The literature assesses the relationship between health and several proxies for social position, mainly focussing on occupational class, income level and educational level. Of these proxies, educational level is most widely used in larger statistical studies of the development in social inequality trends. Numerous studies have indicated that social position, especially educational level, is associated with a wide range of health indicators in countries with available data (Marmot, 2003). The extensive literature on educational health inequalities in health provides opportunities for comparisons between countries and regions. In the majority of existing research, educational inequalities are often measured on an absolute or relative scale (which are also described further in the methods chapter).

Both trends in mortality and self-assessed health have been monitored heavily in European countries. In Western European countries, and eventually also in Eastern European countries, mortality rates have been declining in recent decades, indicating an overall improvement in

European health from 1980 to 2014 (Mackenbach et al., 2018). Nevertheless, this decline in mortality has been faster among the highly educated, resulting in a considerable increase in relative inequalities. This trend is also apparent in European data on less-than-good self-assessed health from ca. 2002 to ca. 2014 (Mackenbach et al., 2018). A recent study of the association between socio-economic status and morbidity in 20 European countries found that educational gaps were greater in high-preventable diseases than low-preventable diseases (Rydland et al., 2020).

2.4.2 Determinants of educational inequalities in health

As the observed inequalities in health are considered problematic, several theories and determinants of health inequalities have been presented in the attempts to explain and understand the mechanisms of distribution of good health. One of the most influential models in the field of inequalities in health is the social determinants of health, which was initially proposed by Dahlgren and Whitehead (1991) and eventually integrated by the World Health Organization (Wilkinson et al., 2003). The model is often referred to as the *rainbow model* (Figure 1), as it illustrates arrays of social determinants that are believed to influence the distribution of health in the population (Dahlgren & Whitehead, 1991). The determinants are presented as a series of four layers, reaching from the major structural environment to individual lifestyle factors. This model offers four levels for policy interventions, focussing on producing long-term structural changes, improving living and working conditions, strengthening social and community support and influencing individual lifestyles and attitudes (Dahlgren & Whitehead, 1991). The age, sex and genetic makeup of each individual are the core of the model and are considered to be fixed factors which are not politically amendable. The influence of this model is evident in the leading determinants of health as presented by the World Health Organization; these include stress, work, unemployment and social support (Wilkinson et al., 2003), and therefore strongly emphasising the need for *social* interventions and policies to combat inequalities in both communicable and non-communicable diseases (Marmot, 2005).

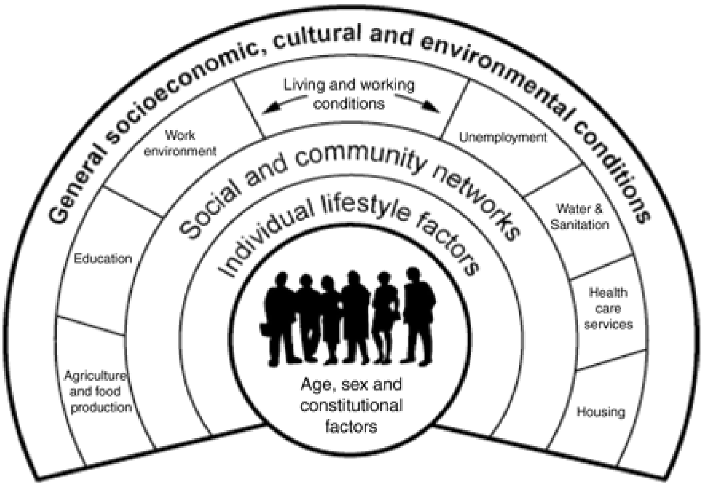

Figure 1: *Social determinants of health, presented in Dahlgren and Whitehead (1991).*

While the model of social determinants of health remains predominant, contemporary theories on social health inequalities have been developed as responses to persistent social inequalities in health. Current explanations and pathways both compliment and challenge the original model, and many move beyond the original model. Mackenbach (2012) offers an overview of the leading contemporary theories, which focus on social mobility, social strata composition, distribution of resources, diffusion of innovations and behaviours, as well as biological disadvantages in early life (Mackenbach, 2012). One of the most influential theories is the fundamental cause theory presented by Link and Phelan (1995), who by not treating socioeconomic status as a mere proxy for 'truer causes lying closer to disease in the causal chain', argue that socioeconomic status is the *fundamental cause* of health inequalities through its embodied resources, such as money, knowledge, power, prestige and beneficial social connections (Link & Phelan, 1995).

2.4.3 Employment as a pathway

One frequently studied pathway from socioeconomic position to health is through employment and working conditions. Overall, lower educational attainment can have consequences for employment opportunities and employment stability, working conditions, work-related benefits and income (Braveman & Gottlieb, 2014; Egerter et al., 2011; OECD, 2021). These factors are all potential health contributors. Numerous studies have reported an association between unemployment and poor physical health (Curtis et al., 2019; Suhrcke & Stuckler, 2012), also within Scandinavian welfare state regimes (Bambra & Eikemo, 2009). This is also the case for job insecurity, which often involves pessimism and a lack of financial security. Job insecurity has been found to be associated with poor self-rated health as well as depression (Ferrie et al., 2005). Furthermore, employees with less formal education are more likely to hold lower paying jobs that include occupational hazards and poor working conditions as well as limited opportunities for control and skill utilisation. This increases their risk of injury, illness and fatality (Egerter et al., 2011; Kaikkonen et al., 2009). People with lower educational attainment are also more likely to be afflicted by societal restructuring, including economic fluctuations, which makes them more vulnerable to unemployment instigated by economic recessions and industry downturns (Edwards, 2008; Egerter et al., 2011).

2.4.4 Social inequalities in health during societal restructuring and crises

In this thesis, I study developments in health during times of societal restructuring. On an aggregated level, the association between social position and health can be affected by greater developments in the society. Existing literature on trends in social inequalities in health during restructuring is mostly related to periods of economic recession; these are periods of decline in general economic activity and are often characterised by rising unemployment.

The epidemiological literature on population health effects of recessions provides mixed findings. Several studies have found health to deteriorate during recessions, on measures such as self-rated health (Abebe et al., 2016; Curtis et al., 2019; Nettleton & Burrows, 1998; Zavras et al., 2013), self-rated mental health (Katikireddi et al., 2012) and mortality (Economou et al., 2008). However, and somewhat surprisingly, many studies have revealed a pro-cyclical relationship between mortality and economic activity in which mortality decreases during economic downturns (Copeland et al., 2015; Gerdtham & Ruhm, 2006; Granados, 2012; Ruhm, 2000). This pro-cyclical relationship has also been reported in Norway (Haaland & Telle, 2013).

Several studies have assessed how socioeconomic inequalities in health have developed during periods of recession. Studies that examine the impact of economic recession on social inequalities in health can tell us something about potential vulnerability of certain groups to health effects of societal restructuring. In their review of studies on this subject up to 2013, Bacigalupe and Escolar-Pujolar (2014) find that the majority of studies report an increase in health inequalities during crisis periods, although not always in both sexes or in all health and socioeconomic variables. In a comparative study between England and Sweden from 1991 to

2010, Copeland et al. (2015) demonstrate that relative educational inequalities in self-reported health increased during recessions among women in both countries and among Swedish men. A repeated cross-sectional study using data from Japan found that relative disparities in self-reported poor health increased between the top and middle occupational groups of men following the economic recession in the 1990s (Kondo et al., 2008).

Conversely, a comparative study between Nordic countries does not support these findings. Based on survey data collected in Finland, Norway, Sweden and Denmark in the 1980s and 1990s, the study illustrates that both relative and absolute educational inequalities in perceived health remained stable throughout a period of economic recession and a sizeable increase in unemployment (Lahelma et al., 2002). Lahelma et al. (2002) argue that welfare state arrangements—including social benefits, such as unemployment benefits at a relatively high compensation level as well as health and social services—likely contributed to addressing and buffering against the structural changes seen during the recession. Considering the Nordic welfare regime setting of this thesis, the arguments regarding its potential buffering effects are presented in the following subsection.

2.4.5 Welfare states as buffers

Nordic welfare regimes, referred to as social democratic regimes by Esping-Andersen (1990), are characterised by universalism and de-commodification of social rights in which manual workers typically enjoy rights identical to those of white-collar employees and civil servants. Nordic countries exhibit greater generosity in social security benefits than other OECD welfare states (Ellingsæter et al., 2020), and Norway is the most generous of the Nordic countries in sickness benefits (Pedersen, 2017). The Nordic welfare state regimes are assumed to buffer against the adverse effects of economic recession and societal restructuring. This protection is, to a large extent, achieved through government investments in social welfare programmes, such as unemployment programmes, health care, old-age pensions and housing support (Stuckler & Basu, 2014). Abebe et al. (2016), in their study on changes in self-rated health before and during the European economic crisis, find that living in welfare-generous countries was significantly associated with a reduced risk of reporting fair and poor self-rated health in all cohorts over time. Stuckler et al. (2009) examined associations between changes in employment and mortality to discover how these associations were modified by social spending on active labour market programmes in 26 European Union countries between 1970 and 2007. They indicate that higher social spending in active labour market programmes, which is often found in Nordic countries, could mitigate some adverse health effects of economic recessions.

Despite the assumed buffering effects of generous welfare benefits, educational inequalities in health are found to persist even in highly developed welfare states, including Nordic welfare regimes (Bambra et al., 2010; Eikemo et al., 2008; Hu et al., 2016; Mackenbach et al., 2018). In Norway, studies have found relative educational inequalities in both mortality, hypertension and smoking to increase in both men and women over time (Ernstsen et al., 2012; Strand et al., 2014), whereas relative inequalities in diabetes and high cholesterol remained stable in both genders over time (Ernstsen et al., 2012).

Mackenbach (2012) identifies potential explanations for this paradox. In his review of nine modern theories that explain health inequalities, he derives two general hypotheses that may aid in explaining the persistence of health inequalities in welfare states. One of these hypotheses is that the lower social strata are now more exclusively composed of individuals with personal characteristics that increase the risk of poor health. This shift has been produced by decades of upward intergenerational social mobility due to changes in the economy and an expansion in higher education. Welfare policies have contributed to a more merit-based educational system in which increased opportunities for social selection may have resulted in lower social groups to become more homogeneous in personal characteristics, such as cognitive abilities and personality profiles. Hereby, Mackenbach argues that the welfare system may have paradoxically contributed to a widening of inequalities in health (Mackenbach, 2012).

2.5 Summary of the study's background

To summarise, this background chapter provided a broad framework for interpreting the health situation and health developments in a coastal population that have faced a substantial restructuring of their society. In addition to an outline of general societal developments in Norwegian coastal areas, I introduced a perspective on health in restructuring societies, as presented by Aase (1993), as well as well-established perspectives on geographical and social inequalities in health. The literature presented in this chapter has been decisive in establishing the aims of this thesis. In the next chapter, the main objective and specific aims of this study are presented.

3 Aims

3.1 Main objective

The overall aim of this dissertation is to examine the health situation and decennial health trends in a Norwegian rural coastal population with a former long-standing dependence on small-scale fishing. The purpose is to assess how this population's overall health level has developed during and following the decline in this key industry and the subsequent restructuring of the local labour market. Special emphasis is given to generational and educational disparities in health.

3.2 Specific aims

Paper I

- To examine the association of geographical affiliation and self-rated health in a Norwegian population
- To investigate the contribution of employment, behavioural and psychosocial factors to this association

Paper II

- To study developments in self-rated health in three generations across four decades in a Norwegian rural coastal area that has undergone local labour market restructuring
- To compare findings from the rural coastal population with those in adjacent areas to assess geographical disparities in self-rated health over time

Paper III

- To examine trends in absolute and relative educational inequalities in self-rated health in a Norwegian rural coastal population
- To compare findings from the rural coastal population with those in adjacent areas to assess geographical differences in educational inequalities in self-rated health over time

4 Data and methods

4.1 Study population

4.1.1 The HUNT Study

The three papers included in this dissertation are based on data from the Trøndelag Health Study (HUNT). The HUNT Study is a comprehensive Norwegian population-based cross-sectional health survey that has been conducted four times to date: 1984–1986 (HUNT1), 1995–1997 (HUNT2), 2006–2008 (HUNT3) and 2017–2019 (HUNT4) (Krokstad et al., 2013; Åsvold et al., 2022). The four HUNT surveys were conducted in the former county of Nord-Trøndelag. All registered inhabitants 20 years and older in this area were invited to participate. The participation rates in the HUNT Study have generally been high. Of the total invited population, participation rates in the four survey rounds were 89.4% (77,202), 69.5% (65,228), 54.1% (50,800) and 54% (56,042), respectively (Åsvold et al., 2022). The HUNT Study has collected data from inhabitants through questionnaires, field station interviews and biological samples.

The HUNT Study is a collaboration between HUNT Research Centre (Faculty of Medicine and Health Sciences, NTNU, Norwegian University of Science and Technology), Trøndelag County Council, Central Norway Regional Health Authority, and the Norwegian Institute of Public Health.

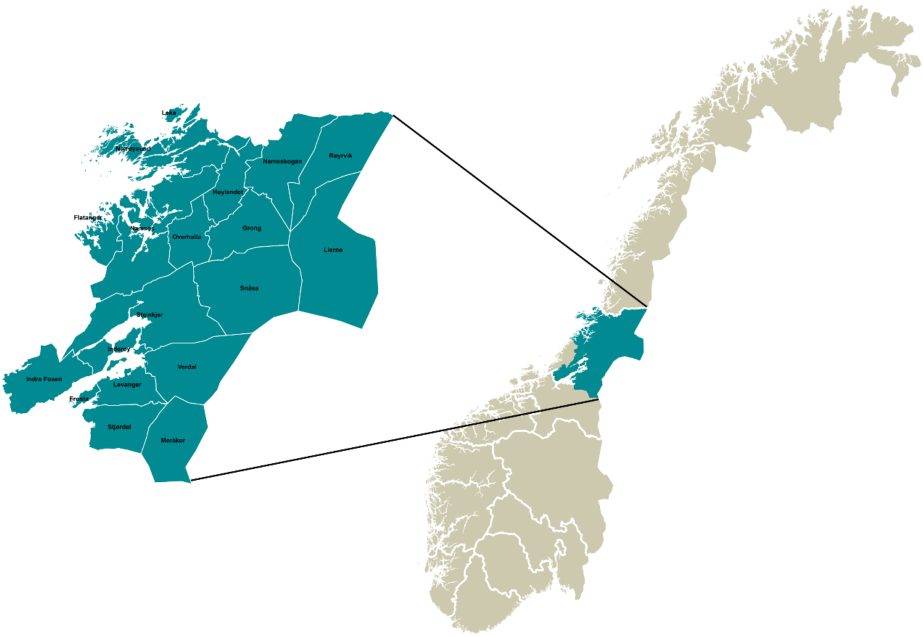

Figure 2*: The Trøndelag Health Study area (Map created by Jon Olav Sliper; map data from Norwegian Mapping Authority).*

The former county of Nord-Trøndelag is located in the central part of Norway (Figure 2). In 2017, the area had approximately 137,000 inhabitants (SSB, 2017). The population of Nord-Trøndelag is generally considered to be demographically representative of the Norwegian population. The area's health and mortality trends are found to generally follow national trends (Krokstad & Knudtsen, 2011). Nevertheless, the area lacks larger cities, and levels of income and education are somewhat lower than the national average (Krokstad & Knudtsen, 2011; Krokstad et al., 2004; SSB, 2020). The population is stable, with little outmigration and a small immigrant population. The area does not constitute an extreme; hence, we considered this population to be adequate for the purpose of this dissertation.

4.1.2 Classification of the coastal population

The most important methodological consideration of this dissertation concerns the definition of the coastal population. To assess geographical health disparities, the study participants were classified into categories based on their registered municipality of residence at the time of invitation to the HUNT Study. In the three included papers, the following geographical categories were used: rural coast, urban coast, rural inland and rural fjord (Figure 3). A full list of the municipalities and their classification is presented in the Appendix.

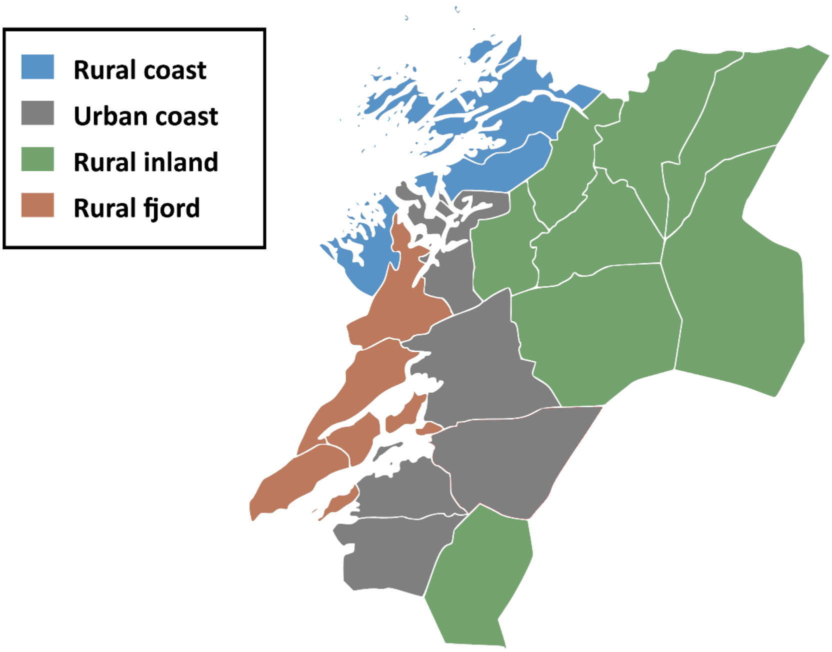

Figure 3*: Classification of the study population in the former Nord-Trøndelag County.*

The former county of Nord-Trøndelag comprised 24 municipalities. The primary interest of this study is the rural coastal areas with a predominant history of small-scale fishing. Five municipalities meet this criterion. These five municipalities share three characteristics related to the coast. First, a substantial proportion of their residents were historically employed in fishing. For these areas, fishing was comprised primarily of small-scale fisheries. In 1960, their proportion of residents employed in fishing ranged from approximately 10% to 27% of the workforce in these municipalities. In all municipalities combined, the proportion was 17% of the total workforce. In the remaining municipalities, employment in fishing was below 5% of the workforce (NSD, 2020).[1] Our definition of rural coastal municipalities aligns with a previous definition of fishery-dependent municipalities in Norway, which operated with a cut-off at 5% employment in fishing (Iversen et al., 2016; Riksrevisjonen, 2020). Second, these five

[1] Data were obtained from the Norwegian Centre for Research Data's (NSD) municipality database. NSD is not responsible for analyses or interpretations in this dissertation.

municipalities border the ocean. They have therefore traditionally been long-standing coastal trading points along historical coastal shipping routes (Herje et al., 1999). Third, the five municipalities have low land-to-coast ratios, with an area average of 0.46 km^2 of land per kilometre of coastline. This entails that inhabitants enjoy a closer physical proximity to the coast than residents in the remaining municipalities in the county.

The remaining municipalities were classified into the geographical categories of urban coast, rural inland and rural fjord. Five municipalities were categorised as urban coastal areas; historically, they were town areas. In 2019, these municipalities had between 13,000 and 24,500 inhabitants (SSB, 2019d). All urban coastal municipalities border the coast, and four are in fjord areas. The total land-to-coast ratio of the urban coastal municipalities is 6.39 km^2 of land per kilometre of coastline. The two remaining categories, rural inland municipalities (eight municipalities) and rural fjord municipalities (from six to five municipalities at HUNT4 due to municipality mergers), have no pronounced history of fishing (1.6% and < 1% of the total workforce in 1960, respectively). However, the rural fjord and inland categories differ significantly in land-to-coast ratio (with no coastline and 4.88 km^2 of land per kilometre of coastline, respectively). Together, these two categories could have been treated as one rural category. Nevertheless, differentiating between the two categories allows for comparisons between areas that differ in their physical proximity to the coastline but have no history of coastal involvement. Considering that previous studies have revealed potentially positive effects of coastal proximity on residents' health (Wheeler et al., 2012; White et al., 2013), the validity of this study is likely strengthened by differentiating between these two areas.

4.1.3 County statistics: Developments in fishing

Table 1 presents statistics regarding developments in fishing and educational levels in the former county of Nord-Trøndelag. Statistics are reported from 1960, 1984 and 2017[2]. Numbers from 1960 are provided to reflect the situation before the greatest downturns in fish stocks. Numbers from 1984 and 2017 provide the status at the time of HUNT1 and HUNT4. Numbers are provided on a county level due to limited historical statistics on a municipality level. The supplementary material for Paper I provides more detailed statistics on developments in fishing from 1960 to 2006, both on county and municipality levels. As illustrated in Table 1, the number

[2] Data are derived from Statistics Norway and The Norwegian Directorate of Fisheries.

of registered fishers and vessels dropped substantially between 1960 and 1984 and continued to drop through 2017. Employment in aquaculture was minor or non-existent in 1960 and 1984 but increased to 551 workers by 2017. The general level of education in the county has also increased substantially.

***Table 1**: Inhabitants, fishing activity and educational levels in the former Nord-Trøndelag County in 1960, 1984 and 2017*

	1960	1984	2017
Registered inhabitants	116,642	127,051	137,233
Registered fishers	2,506	662	253
Registered vessels	1,575	861	153
Vessels below 11 metres[1] in length	1,499	779	130
Employed in aquaculture	*No data available*	*No data available*	551
Inhabitants with a college or university education (by percent)	5[2]	9.2	26.6

[1] *All vessel lengths from 1960 were converted from feet to metres, which is the new standard.*
[2] *Data are from 1970.*

4.2 Study variables

4.2.1 Self-rated health

Self-rated health was the outcome measure of health in all three papers. Self-rated health is a widely used health measure intended to capture an individual's general health. In view of the limited studies conducted on coastal population health, a wide measure of health, such as self-rated health, is useful in initial studies regarding health developments in rural coastal areas. There is no universally agreed-upon definition of health, and study participants therefore have considerable freedom in their evaluations of their own health status. Consequently, self-evaluations of health are prone to modification by factors such as age and culture (Jylhä, 2009). Nevertheless, self-rated health is still considered a valid measure of health status. Its validity has been confirmed through numerous studies that indicate its strong predictive ability for both mortality, morbidity and work-related disability (DeSalvo et al., 2006; Idler & Benyamini, 1997). The HUNT Study's original variable for self-rated health was measured in questionnaires as follows: 'How is your health at the moment?' Four response alternatives were provided: 'Poor', 'Not so good', 'Good' and 'Very good'. The original variables were highly skewed in all four surveys of the HUNT Study, with few participants responding that they were in ‘poor’ health. Therefore, the original variable and its four responses were merged into a dichotomous variable: the responses ‘Poor’ and ‘Not so good’ were merged into ‘Poor self-rated health’, and the responses ‘Good’ and ‘Very good’ were merged into ‘Good self-rated health’. In all analyses, ‘Good self-rated health’ functioned as the reference group.

4.2.2 Geographical affiliation

As presented in Section 4.2.1, geographical affiliation was assigned based on participants’ registered municipality of residence at the time of invitation to the HUNT Study. The four categories were rural coast, urban coast, rural inland and rural fjord. A more finely grained geographical categorisation based on postcodes was considered in this study but dismissed due to a potential violation of anonymisation. As the data contain information on participants’ occupation and education, postcodes from the database can threaten anonymisation in sparsely populated areas.

4.2.3 Educational level

In Paper III, trends in social inequalities were assessed. Educational level was chosen as the indicator of socioeconomic position because it is a stable measurement attained early in adult life. Moreover, educational level is maintained even if one exits the labour market or changes occupation. HUNT1, HUNT2 and HUNT4 requested participants’ educational level, although HUNT3 did not. The original set of variables on educational level comprised eight (HUNT1), five (HUNT2) and six (HUNT4) categories, which were collapsed into three levels based on the educational classifications of ISCED11 and NUS2000 (Barrabés & Østli, 2016): primary (primary and lower secondary school), secondary (upper secondary and post-secondary school) and tertiary (first and second stages of tertiary education). Comparisons of educational categories from the HUNT surveys and the classification used in Paper III are presented in Table 2.

Table 2*: Comparisons of educational categories used in the Trøndelag Health Study (HUNT) and in Paper III*

<table>
<tr><th>HUNT1 (1984–1986)</th><th>HUNT2 (1995–1997)</th><th>HUNT4 (2017–2019)</th><th>Classification of education in Paper III</th></tr>
<tr><td>Seven years of primary school or less</td><td rowspan="4">Primary school of between seven and ten years, continuation school or folk high school</td><td rowspan="4">Between nine and ten years of compulsory primary and lower secondary school</td><td rowspan="4">Primary education</td></tr>
<tr><td>Middle school</td></tr>
<tr><td>Nine years of compulsory primary and lower secondary school</td></tr>
<tr><td>Ten years of primary and lower secondary school</td></tr>
<tr><td>One or two years of upper secondary school</td><td>High school, intermediate school, vocational school or between one and two years of high school</td><td>One or two years of academic or vocational school</td><td rowspan="3">Secondary education</td></tr>
<tr><td rowspan="2">General certificate of education, commercial college or sixth-form college</td><td rowspan="2">University qualifying examination, junior college or A-level exams</td><td>Three years of academic or vocational school</td></tr>
<tr><td>Between three and four years of vocational school or apprentice (upper secondary or sixth-form college)</td></tr>
<tr><td>College or university, less than four years</td><td>University or other post-secondary education, less than four years</td><td>College or university, less than four years</td><td rowspan="2">Tertiary education</td></tr>
<tr><td>College or university, four years or more</td><td>University or college, four years or more</td><td>College or university, four years or more</td></tr>
</table>

4.2.4 Covariates in Paper I

Paper I presents an assessment of the relative contribution of a range of factors to the association between geographical affiliation and health status. Analyses were based on data from HUNT3. The covariates of this paper were categorised as either employment, behavioural or psychosocial factors. These variables are described in the paper and are presented in further detail in the following subsections.

4.2.4.1 Employment factors

Class affiliation was derived from each participant's reported occupation. Occupation was requested in field station interviews in which participants were asked to provide information on their current or former occupation. The original variable comprised 10 categories based on the International Standard Classification of Occupations – ISCO-88 (SSB, 1998). This variable was condensed into a six-level scale based on the Erikson Goldthorpe class scheme (Erikson & Goldthorpe, 1992), presented in Table 3.

***Table 3**: Comparisons of occupational categories used in the Trøndelag Health Study (HUNT) and in Paper I*

Classifications of occupation in HUNT3 (2006–2008)	Classifications of occupation in Paper I
Legislators, senior officials and managers	I
Professionals	
Technicians and associate professionals	II
Clerks	III
Service workers and shop and market sales workers	
Skilled agricultural and fishery workers	IV
Craft and related trades workers	V + VI
Plant and machine operators and assemblers	VII
Elementary occupations	
Armed forces and unspecified	Not included in analyses

The original occupational variable provided no distinction for self-employed workers in primary production; therefore, all employment in farming, forestry and fishing was categorised as Class IV. In Paper I, this was set as reference group to provide comparisons to this group.

Employment reflects the employment status of participants and was requested during field station interviews from participants under the age of 70. Participants were asked to answer yes or no to whether they were employed, in education or worked as a stay-at-home parent. Based on this information, all participants under the age of 67 were classified as 'employed', 'in education' or 'unemployed'. All participants over the age of 67, which is the standard Norwegian retirement age, were categorised as 'retired'. Hereby, participants who were excluded from the original employment question (cut-off for this question was 70 years of age) were included in the final variable for employment. Participants who reported that they were both employed and in education were categorised as ‘in education’. For analyses in Paper I, those in the employed category were set as the reference group, as it represents a perceived standard status of employment.

Job sector was included as an indicator of physical strain in participants’ workplace, and this information was requested in field station interviews in which participants were asked to categorise their current or former occupation within a list of 16 industries. This variable was then classified into ‘primary sector’, ‘secondary sector’ and ‘tertiary sector’ (Table 4).

***Table 4**: Comparisons of work sector categories used in the Trøndelag Health Study (HUNT) and in Paper I*

Classifications of work sector in HUNT3 (2006–2008)	**Classifications of work sector in Paper I**
Fishing or fisheries	Primary sector
Farming and forestry	
Construction	Secondary sector
Mining	
Industry (not including oil and gas; for example, food, textiles, wood, metal, mill or printing)	
Industry, supplier, or contractor in oil and gas industry	
Oil and gas extraction	
Power and water supplier	
Trade (not including oil and gas; for example, shops, automobile industry or workshops)	Tertiary sector
Health and social welfare	
Hotel and restaurant industry	
Bank, insurance, realty and finance (including car rental and other rental services, IT services or office work)	
Public management and defence (for example, county, police, fire department, labour and welfare administration)	
Transportation (land, sea or air)	
Teaching	
Other (for example, renovation, newspaper, radio and TV, hairdresser, beautician or undertaker)	

4.2.4.2 Behavioural factors

The *smoking status* variable in Paper I comprised four categories for smoking status: ‘never smoked’, ‘former smoker’, ‘daily smoker’ and ‘occasional smoker’. This variable was originally constructed from reported answers regarding current smoking status and included both cigarettes and cigar pipes. Daily smoking, even at low quantities, is associated with a substantially increased risk of developing coronary heart disease and stroke (Hackshaw et al., 2018); hence, smoking status was considered an equally valid measurement of smoking as variables that measure the *quantity* of cigarettes smoked.

Alcohol consumption was originally measured through three questions in which participants were asked to report the respective units of beer, wine and spirits consumed over the past two weeks. Based on the total sum, categories of 'abstinent', 'moderate' (between one and 14 drinks in two weeks) and 'excessive' (> 14 drinks in two weeks) were derived.

Physical activity was derived from two questions in which participants were asked to report the number of hours per week spent on light and vigorous physical activity during leisure time, with possible answers of 'none', 'less than 1 hour', '1–2' or '3 or more'. Vigorous physical activity was given twice as much weight as light physical activity, and the combined aggregate was classified into a variable with three categories: 'inactive' (0–1 h per week), 'moderately active' (2–5 h per week) and 'active' (6–9 h per week).

4.2.4.3 Psychosocial factors

Help from friends was measured through the following question: 'Do you have friends that can help you when you need them?' Possible answers were yes and no.

Sense of community was measured through this statement: 'I feel a strong sense of community with the people who live here'. The five original answers to this question were dichotomised into 'yes' ('strongly agree' and 'somewhat agree') and 'Uncertain/disagree' ('not sure', 'somewhat disagree' and 'strongly disagree').

Anxiety and depression symptoms were measured on the Hospital Anxiety and Depression Scale (HADS), an established self-rating instrument comprising 14 four-point Likert-scaled items; seven of them measure anxiety (HADS-A), and seven of them measure depression (HADS-D) (Mykletun et al., 2001; Stern, 2014). Participants answered 14 questions regarding mental distress in which the total scores placed participants on a scale from 0 to 21. These scores were dichotomised at the recommended cut-off at ≥ 8 (Stern, 2014). For the analyses in Paper I, anxiety and depression symptoms were included as potential predictors of self-rated health. As discussed in the paper, one could anticipate that respondents already have taken their mental health into account when reporting their own health (Au & Johnston, 2014), thus challenging its role as a predictor of self-rated health. Still, the causal relationship between these variables is complicated, which is also seen with physical activity as a predictor of health (Bauman et al., 2012). Symptoms of anxiety and depression have been found to play a mediating role between community characteristics and health, and an inclusion of this covariate may aid in illuminating the underlying mechanisms of geographical affiliation and self-rated health; the rural coastal population may be more exposed to psychosocial distress, which is recognised as an important factor in major physical health outcomes (Matthews & Gallo, 2011).

4.3 Missing data

Missing data were handled through full information maximum likelihood (FIML) in Paper I and through multiple imputation in Paper III. With FIML, missing data are not replaced or imputed; rather, they are estimated through a likelihood function for each individual based on the variables that are present. Hereby, all available data are utilised, and the same results are produced every time. FIML is found to be an adequate alternative to multiple imputation (Peyre et al., 2011). In Paper II, only complete cases were included. In paper III, we did not have data on participant's educational level at HUNT3, as this was not obtained; therefore, if HUNT3 participants had participated in other HUNT Study surveys, then any missing data for educational level were imputed if available. Of the 50,807 participants in HUNT3, 45,500 of these had available data for education from another survey. The remaining missing values for education in HUNT3 as well as for the remaining surveys were handled through multiple imputation. Missing data are discussed further in Chapter 6.2.

4.4 Ethical considerations

The data utilised in this study were collected in the four HUNT surveys. All participants in the HUNT surveys provided their consent for data collection, storage of data in the HUNT databank as well as linkage to several national and local registers. The HUNT Study was approved by the Norwegian Data Protection Authority (Datatilsynet) (HUNT1, HUNT2 and HUNT3) and the Regional Committee for Medical and Health Research Ethics (REC) Central Norway (HUNT2 and HUNT3). Since 2018, the HUNT Study has been covered by regulations on population-based health surveys.[3] The current study has been approved by the Regional

[3] Regulations on population-based health studies - Lovdata

Committee for Medical and Health Research Ethics (REC) North Norway with the project no. 2018/1009.

4.5 Statistical analyses

The dichotomised variable of self-rated health is the outcome in the three papers included in this thesis. The characteristics of the study population are presented in all papers. The statistical analyses were based on logistic regression (Paper I) and Poisson regression (Papers II and III). Statistical significance was assessed through 95% confidence intervals (Papers I and II) and *p*-values (Paper III). Data were analysed using Mplus version 8 (Paper I) and Stata 16.1 (Papers II and III). An overview of methods in this thesis is presented in Table 5.

***Table 5**: Overview of methods in thesis*

	Paper I	Paper II	Paper III
Type of study	Cross-sectional	Repeated cross-sectional	Repeated cross-sectional
Data	HUNT3	HUNT1–HUNT4	HUNT1–HUNT4
Inclusion criteria	All participants with data on self-rated health and municipality affiliation	All participants (complete cases)	All participants over 30 years of age with data on self-rated health
Outcome	Self-rated health	Self-rated health	Self-rated health
Predictors	Geographical affiliation Age Sex Employment factors Behavioural factors Psychosocial factors	Geographical affiliation Age Sex	Geographical affiliation Age Sex Educational level
Statistical method	Logistic regression	Poisson regression	Poisson regression
Missing data handling	Full information maximum likelihood (FIML)	Complete case analysis	Multiple imputation
Supplementary analyses	Analyses stratified by gender	-	Analyses stratified by gender

4.5.1 Paper I

In Paper I, HUNT3 data were utilised to assess the relative contributions of employment, behavioural and psychosocial factors to the association between geographical affiliation and self-rated health. Logistic regression models were specified to examine associations between self-rated health and geographic affiliation; we regressed poor self-rated health on geographical affiliation (the urban coastal population set as reference category) and adjusted for age and gender.

The paper included nine models, eight of which were part of stepwise and simultaneous adjustments for employment, behavioural and psychosocial factors. In the first of the eight models, functioning as reference model, odds ratios (ORs) were calculated for geographical categories, adjusted for age and gender. This model was further adjusted for employment, behavioural and psychosocial factors separately, adjusted for combinations of two groups, and finally, adjusted for all factors simultaneously. The primary interest in these analyses was the change in OR for each geographical category from the original estimations in the reference model. For each adjustment, the OR for each geographical category changed, and the percentage change in ORs between models was calculated for each geographical category with the following formula:

$$[100\ x\ (OR\ reference\ model - \ OR\ individual\ factors)/(OR\ reference\ model - \ 1)]$$

The calculated changes in ORs were reported in percentages; these changes express the amount that the estimated excess likelihood of reporting poor self-rated health in each geographical category was reduced from the reference model.

This method of stepwise adjustment for factors and the subsequent assessment of change in measured association has previously been used to study several health measures (Skalická et al., 2009; Stronks et al., 1996; van Hedel et al., 2018; van Oort et al., 2005), which allows an assessment of both independent and overlapping contributions of factors. The independent effects of each factor were calculated by comparing a model with two groups of factors and the corresponding two models each with one group of factors; the percentage reduction in the OR of the model that did not have a specific factor was subtracted from a model that included this factor. This is described in more detail in the following example, which is similar to the explanation provided by van Oort et al. (2005):

$$Model\ 1: Geographical\ affiliation + age\ and\ gender + employment\ factors$$

$$Model\ 2: Geographical\ affiliation + \ age\ and\ gender + psychosocial\ factors$$

$$Model\ 3: Geographical\ affiliation + age\ and\ gender + employment\ factors + psychosocial\ factors$$

The independent contribution of psychosocial factors is calculated as the percentage change of the ORs for geographical affiliation that is attributable to the inclusion of psychosocial factors (Model 3) in a model that already contains employment factors (Model 1). The independent contribution of psychosocial factors is therefore calculated as the percentage reduction in the ORs in Model 3 minus the percentage reduction in the ORs in Model 1. Overlapping effects were then derived similarly—by subtracting the independent contribution of a specific factor from the total contribution of that factor. In this example, the total contribution of psychosocial factors equals Model 2; thus, overlapping effects are calculated as follows:

$$Model\ 2 - Independent\ effects\ of\ psychosocial\ factors$$

The calculation of overlapping effects in previous studies has been used to assess potential indirect effects between factors (Skalická et al., 2009; Stronks et al., 1996; van Oort et al., 2005). In this paper, overlapping effects are defined as indirect contributions of one factor through another. If the overlaps are ignored, then one could risk overestimating individual effects of factors. However, it should be noted that this paper is a cross-sectional study, and although calculations may indicate potential indirect contributions, causation and mediation are not proved through this methodology.

4.5.2 Paper II

In Paper II, data were gathered from all four cross-sectional surveys of the HUNT Study to assess trends in self-rated health at three ages in four geographical categories. We fitted a Poisson regression model with robust variance estimates for each of the four HUNT surveys, with self-rated health as the dependent variable and gender, age at participation (continuous) and geographical affiliation (rural coast set as reference category) as predictors. The robust Poisson regression was chosen due to its recognised adequacy for handling binary outcomes, especially when the prevalence of the outcome is low and when the model contains continuous covariates (Chen et al., 2018; Huang, 2022).

To capture gender disparities in health between generations, also between geographical categories, we estimated a three-way full-factorial regression model, allowing for interactions between all covariates. We tested each model for quadratic interactions of age, and Wald tests revealed statistically significant quadratic functions of age in all four models. Calculations indicated that the vertex of the parabola was outside the range of relevant values for age in all models, indicating curvilinear relationships between health and age without turning points within the observed age range. The final models were calculated as follows:

$$\log(Y) = constant + \beta_1 Age + \beta_2 Gender + \beta_3 Geography + \beta_4 Age\_Age + \beta_5 Age\_Gender + \beta_6 Age\_Geography + \beta_7 Gender\_Geography + \beta_8 Age\_Gender\_Geography + error$$

From all four Poisson regression models, HUNT1 to HUNT4, the predicted prevalence of poor self-rated health was estimated at three ages (20, 45 and 70) for each geographical category. This estimation of predicted prevalences at certain ages is also known as adjusted predictions at representative values (APRs) (Williams, 2012). Additionally, marginal effects (at representative values—MERs) of geographical affiliation were calculated for each age. Marginal effects provide an approximation of the amount of change in the outcome probability that will be produced by a one-unit change in the independent variable (Williams, 2012). In this study, the calculated marginal effects were the difference in the adjusted predictions for each geographical category (with rural coast as the reference), given the specific values of age. We also calculated the marginal effects of gender contrasted between geographical categories (with rural coast as the reference) to test for statistically significant differences in gender effects between the geographical categories. Both adjusted predictions at representative values and marginal effects at representative values were calculated using the margins postestimation command in Stata version 16.1. Changes in predicted prevalence and marginal effects of geographical affiliation from HUNT1 to HUNT4 were calculated.

4.5.3 Paper III

In Paper III, we used data from all four HUNT cross-section surveys to examine trends in absolute and relative educational inequalities in self-rated health. Age-standardised prevalence of poor self-reported health was calculated for all geographical categories for all cross-sections using 10-year age groups.

Absolute and relative educational inequalities in self-rated health were estimated using the slope index of inequality (SII) and relative index of inequality (RII), respectively. These regression-based measures of health inequalities provide absolute and relative differences in the prevalence of the outcome between respondents with the lowest educational level and with the highest educational level (Mackenbach & Kunst, 1997). Educational level was assigned a ridit score, ranging from 0 (highest level of education) to 1 (lowest level of education). The ridit score was based on the midpoint of the range in the cumulative distribution of the participants in the given category. SII values greater than 0 and RII values greater than 1 indicate that the outcome is more prevalent among individuals with lower education than individuals with higher education.

We calculated both SII and RII using robust Poisson regressions with identity and log link functions, respectively (Moreno-Betancur et al., 2015). SII and RII were estimated by regressing self-rated health on the ridit score. Models were adjusted for age and gender and estimated with 95% confidence intervals.

$$g(Y) = constant + \beta_1 Ridit + \beta_2 Age + \beta_3 Survey + error$$

The coefficient β1 is the coefficient of interest. This expresses RII when the link function is log and SII when the identity link is used. Estimations were calculated separately for each HUNT survey, and trends were assessed by pooling the four surveys and including a two-way interaction term between the ridit score and survey (Ernstsen et al., 2012; Mondor et al., 2018). To test for gender differences in RII and SII in each survey, we included a two-way interaction term between the ridit score and gender for each survey. To test for gender differences in RII and SII trends over time, we included a three-way interaction term between the ridit score, gender and survey (Ernstsen et al., 2012).

5 Results: Papers I–III

5.1 Paper I

Understanding coastal public health: Employment, behavioural and psychosocial factors associated with geographical inequalities. The HUNT Study, Norway

When adjusting for age (continuous) and gender, we found that the rural coastal population (OR 1.53, 95% CI 1.43–1.65) and rural fjord population (OR 1.23, 95% CI 1.15–1.30) exhibited statistically significant higher odds of reporting poor self-rated health compared with the urban coastal population (functioning as a reference category). Non-overlapping confidence intervals of the rural coastal and rural fjord ORs indicated statistically significant differences in the odds of reporting poor self-rated health between these groups. The rural inland population (OR 1.05, 95% CI 0.99–1.12) exhibited no statistically significant difference in the odds of reporting poor self-rated health compared with the urban coastal population.

The higher odds of reporting poor self-rated health in the rural coastal and rural fjord population remained statistically significant after adjustment for individual factors, both for each group of factors and for all groups combined. In the rural coastal population, adjusting for behavioural factors provided the largest reduction in the OR of reporting poor self-rated health (17%), which were followed by employment factors (13%), whereas adjusting for psychosocial factors had no impact on the OR. In the rural fjord population, adjusting for employment factors provided the largest reduction in OR (22%), which were followed by behavioural and psychosocial factors (both 9%).

By simultaneous adjustment for the individual factors, we assessed overlapping effects between factors to the association between geographical affiliation and reporting poor self-rated health (in this paper, we also referred to this as indirect contribution of one factor through another). These adjustments revealed differing independent and indirect contributions of factors between the geographical populations. In the rural coastal population, results indicated that none of the contribution of employment factors to the odds of reporting poor self-rated health was through psychosocial factors, whereas 5 percentage points of the contribution of employment factors was through behavioural factors and 2 percentage points of the contribution of behavioural factors was through psychosocial factors.

5.2 Paper II

Public health in restructuring coastal communities: Generational trends in self-rated health following the decline in small-scale fishing. The HUNT study, Norway

We found a higher predicted prevalence of poor self-rated health in rural coastal adults and elderly people compared with other geographical areas across all decades. However, trends revealed improving self-rated health in rural coastal adults and elderly, as well as narrowing health gaps between the rural coastal population and those in the remaining geographical areas in this Norwegian setting.

In HUNT1, youths (age 20) in rural coastal areas exhibited the highest prevalence of poor self-rated health among the four geographical categories. In HUNT4, the highest prevalence in youths was in rural fjord areas. Youths of all geographical areas showed a substantial increase in poor self-rated health from HUNT1 to HUNT4, with the biggest change in rural fjord youths (+173%), which was followed by urban coast youths (+164%), rural inland youths (+137%) and rural coast youths (+133%). Marginal effects of geographical affiliation (with rural coast set as the reference) indicated no statistically significant differences in poor self-rated health among youths between geographical areas across all surveys.

In adults (age 45), the rural coast population exhibited the highest predicted prevalence of reporting poor self-rated health among the four geographic areas across all four surveys of the HUNT Study. The prevalence of poor self-rated health decreased in all geographic areas from HUNT1 to HUNT4, with the biggest change in rural coast adults (-19%), which was followed by rural fjord adults (-16%), urban coast adults (-11%) and rural inland adults (-10%). Marginal effects of geographical affiliation showed statistically significant negative effects for all geographical categories (with rural coast set as reference) on poor self-rated health across all decades. The negative marginal effects of geographical affiliation declined notably from HUNT1 to HUNT4 for all geographical categories: urban coast with 38%, rural inland with 37%, and rural fjord with 33%. Declining marginal effects indicated narrowing gaps in self-rated health between rural coast adults and those in other geographical categories.

The findings for elderly respondents (age 70) were similar to those for adults. Elderly people in rural coast areas exhibited the highest predicted prevalence of reporting poor self-rated health among the four geographical areas across all surveys. Elderly in all geographical areas exhibited a substantial decrease in poor self-rated health from HUNT1 to HUNT4, with the biggest change in rural fjord elderly (-38%), which was followed by rural coast elderly (-37%), urban coast elderly (-35%) and rural inland elderly (-25%). Marginal effects of geographical affiliation showed statistically significant negative effects of all geographical categories (with rural coast set as reference) on poor self-rated health across all decades. The negative marginal effects of geographical affiliation for elderly declined notably from HUNT1 to HUNT4 across all geographical categories: urban coast with -42%, rural inland with -61%, and rural fjord with -34%. Declining marginal effects indicated narrowing gaps in self-rated health between rural coast elderly and those in other geographical categories.

At all three ages, marginal effects for gender suggested no statistically significant differences in gender effects on poor self-rated health between geographical categories.

5.3 Paper III

Trends in absolute and relative educational inequalities in health during times of labour market restructuring in coastal areas: The HUNT Study, Norway

The unadjusted prevalence of poor self-rated health decreased from HUNT1 to HUNT4 in all geographic areas. Educational levels increased in all areas over the same period. Of the four geographic areas, the rural coastal population exhibited the largest age-standardised prevalence of poor self-rated health in all educational groups across all surveys.

The rural coastal population exhibited the largest absolute (SII) educational inequalities in self-rated health compared with the other geographic regions at HUNT1. From HUNT1 to HUNT2, the absolute inequalities in rural coastal areas increased, while they decreased from HUNT2 to HUNT4. In sum, absolute educational inequalities were larger at HUNT4 than at HUNT1. The remaining geographical regions also exhibited larger absolute educational inequalities in health at HUNT4 than at HUNT1. The smallest increase in SII was in the rural coastal population (19.7%), and the largest increase was in the rural fjord population (83.7%). In HUNT4, absolute educational inequalities in self-rated health in the rural coastal areas were smaller than in rural fjord areas.

The rural coastal population exhibited the largest relative (RII) educational inequalities in self-rated health compared to all other geographic regions at HUNT1. From HUNT1 to HUNT4, relative inequalities decreased steadily in the rural coastal population (-22.8%). In HUNT4, relative educational health inequalities in rural coastal areas were smaller than in urban coastal and rural fjord areas. The rural inland population exhibited a development similar to the rural coastal population (-23.8%). The urban coast and rural fjord populations exhibited relative inequalities at HUNT4 equal to or higher than at HUNT1 (0% and +9.5%), respectively.

Tests for gender differences at each survey revealed statistically significant differences between genders only in SII at HUNT4 in the rural coastal population; men exhibited smaller absolute inequalities in poor self-rated health than women. Gender differences in trends were found in the rural coastal population, where the development in absolute inequalities over time was significantly smaller for men than women.

6 Discussion

6.1 Main findings

The overall aim of this study was to examine the health of a Norwegian rural coastal population with a long-standing history of small-scale fishing and to assess how population health has developed in this population since the decline of this industry. The main findings can be summarised as follows:

- The rural coastal population exhibited greater odds of reporting poor self-rated health than those in adjacent areas (urban coast, rural inland and rural fjord). This finding remained after controlling for age and gender as well as employment, behavioural and psychosocial factors.
- Of the three categories of factors mentioned above, behavioural factors were found to be the biggest contributor to poor rural coastal self-rated health, which were closely followed by employment factors. Still, the majority of the association between rural coastal affiliation and poor health remained after controlling for all three groups of factors.
- The rural coastal population exhibited a higher predicted prevalence of poor self-rated health in adults and elderly people than those in adjacent geographical areas across four decades. We found no statistically significant differences in youth self-rated health between geographical areas.
- The self-rated health of rural coastal adults and elderly has improved over time, and the health gaps between the rural coastal population and adjacent populations have narrowed in these age groups over the course of the HUNT surveys.
- Compared with adjacent geographical areas, developments in educational inequalities in self-rated health have generally been more favourable in the rural coastal population. Relative educational inequalities in self-rated health have decreased steadily in the rural coastal population over the course of the HUNT surveys. Additionally, the rural coastal population exhibited the smallest increase in absolute educational inequalities in self-rated health among the four geographical categories, where stratified analysis revealed that rural coastal men exhibited a substantial decline in absolute inequalities.

In the following section, strengths and limitations related to the study design are discussed. Then, a general interpretation and discussion of findings is provided. Most importantly, this includes a comparison of the findings with existing literature and a discussion of possible explanations for the observed health developments in rural coastal areas. Finally, the implications of the findings and future perspectives are discussed.

6.2 Methodological considerations

The current study has an epidemiological study design with a descriptive (or associative) aim. The analyses were performed using cross-sectional data. In Paper I, data from the HUNT3 cross-sectional survey were analysed, providing a snapshot of the association between geographical affiliation and self-rated health at a single point in time. Papers II and III used a repeated cross-sectional design and provide results on population or group changes over time, also known as aggregate change.

This thesis is an observational study, which entails measuring the chosen outcome with no attempt to affect this outcome. Papers II and III present the developments in health and health inequalities over time, respectively—against the backdrop of societal restructuring. Hence, the aim is not to demonstrate causality between restructuring coastal labour markets and changes in the outcome of this study. The current study design also has limitations regarding accuracy and generalisability, and these are discussed below.

6.2.1 Precision (lack of random error)

Random errors are often said to represent the aspect of chance in statistics and epidemiology (Rothman et al., 2021). This includes concepts such as sampling variability, mismeasurements, and unexplained variations in occurrence measurements. Random errors, which are unavoidable, represent the uncertainty of the estimates that remain after systematic errors have been eliminated. Random errors mainly affect precision. Hence, a study with few random errors results in precise effect estimates. By increasing the sample size, random errors decrease and the precision of a study increases.

The HUNT Study includes a considerable number of participants across all four surveys. Therefore, in the present study, the samples are generally large. This has likely contributed to high precision of the estimates. In our analyses, we used 95% confidence intervals to assess the precision of the point estimates. The width of the confidence intervals varies between the three papers in this thesis, which indicates varying degrees of precision between analyses. The usage of stratification, especially by gender, reduces sample sizes and may therefore reduce precision. Consequently, wider confidence intervals are observed in some subgroups in the stratified analyses.

6.2.2 Validity (lack of systematic error)

The validity of a study reflects the extent to which it measures what it intends to measure. In other words, whether the measurement corresponds accurately to the real world (Rothman et al., 2008). Validity can be both internal and external. Internal validity refers to the extent to which the findings are representative of the population being studied, while external validity refers to the generalisability of findings to other populations.

6.2.2.1 Internal validity

Internal validity refers to whether findings are representative of the population of interest. The most common types of systematic errors and threats to internal validity are selection bias, information bias and confounding. These concepts are discussed in the following paragraphs.

<u>Selection bias and non-participation</u>

Selection bias is a systematic error primarily caused by sources that influence study participation. This includes either the procedure used to select participants or factors that influence study participation. Selection bias is critical if the association between exposure and outcome differs between participants and non-participants (Rothman, 2012). Previous studies have found that participation in epidemiological studies varies within demographic characteristics and groups (Galea & Tracy, 2007), thus increasing the risk of selection bias.

In the HUNT Study, the total adult population of the former Nord-Trøndelag County was invited to participate. Thus, no selection bias was introduced in the distribution of invitations to the study. The participation in the four surveys were 77,202 (89.4%), 65,228 (69.5%), 50,800 (54.1%) and 56,042 (54%), respectively, which demonstrates that the response rate declined throughout the four HUNT surveys and stabilised at 54% of the invited population in HUNT4. The trend of declining participation rates has also been observed in other epidemiological studies (Galea & Tracy, 2007). The participation rate of approximately 54% in the third and fourth HUNT surveys is considered high for a total population survey; nevertheless, the reduction in participation increased the risk of introducing biases. In a non-participant study following HUNT3, non-participants were found to exhibit higher levels of both mortality and several chronic diseases compared with those who participated. Non-participants also had lower socioeconomic statuses than participants (Langhammer et al., 2012). This can induce a healthy participant bias. Nonetheless, the non-participant study revealed no significant differences in poor self-rated health between participants and non-participants. Moreover, illness was not reported as a common reason for not participating in the study. Only 3.7% reported that illness prevented them from participating, while 53.7% reported 'not having time' to participate (Langhammer et al., 2012).

Information bias

Information bias arises from systematic measurement errors which occur due to misclassification of measurements and self-reporting bias (Althubaiti, 2016). In most epidemiological studies, measurements are used to divide participants into defined categories or to label them diagnostically. This involves a risk of placing people into the wrong category or group, which is called *misclassification*. Misclassification is defined as *non-differential* if the probability of being misclassified is the same across study groups and subjects and is unrelated to the value of other study variables, such as exposure, outcomes and confounders. If the probability of misclassification is related to the value of other study variables, then the misclassification is referred to as *differential* (Rothman et al., 2008). Misclassifications can lead to both over- and underestimated effect sizes.

Generally, information collected through self-reporting is susceptible to reporting bias and may be over- or underestimated. In a population study, such as the HUNT Study, questions in the surveys may be interpreted differently by participants. Reporting can differ systematically between age groups, sexes and socioeconomic statuses, and the understanding of the questions may differ. This increases the risk of differential misclassification. In this thesis, variables such as geographical affiliation, age and sex are considered to be accurate and likely to have few measurement errors. The greatest potential source of information bias in this thesis is a misclassification of categorical and dichotomous measures, such as behavioural factors and socioeconomic position, which are used in Papers I and III, as well as the outcome variable of self-rated general health.

Misclassification of exposure

In this section, I discuss potential misclassifications of exposures. I do not go into details on every exposure used in the analyses.

In Paper III, we used education as a proxy for socioeconomic position. Educational level was based on self-reported answers from the HUNT questionnaires, which means that the information was susceptible to reporting bias. Still, we generally considered this information to be correctly reported. With younger participants, one risks systematically misclassifying respondents to lower socioeconomic positions, as their highest level of education may not yet have been attained. In Paper III, we operated with a cut-off at 30 years of age to avoid this misclassification. In the earlier HUNT surveys, educational level was perhaps a slightly incorrect measure of socioeconomic position for women, as fewer women attained higher education at that time. Nevertheless, educational health differences have been widely studied over decades, and using this variable provides opportunities for comparisons with existing literature, also in women.

The education variables have been influenced by the great transformation in the Norwegian educational system after the mid-20th century, which involved changes in the length of required primary schooling as well as changes in both secondary and tertiary education. Thus, through the four HUNT Study surveys, the questions that seek information on educational levels have changed. This can introduce potential misclassifications when condensing the original education variables into three levels. Categories from the different HUNT surveys did not necessarily overlap, and cut-offs were therefore unclear. This may have contributed to misclassification in this study. Nonetheless, I believe that by collapsing the education variables into three levels, we minimised the potential bias introduced by the changes in the educational system and the subsequent changing questions throughout the HUNT surveys.

In Paper I, self-reported lifestyle variables were included as exposures in the analyses. Participants in epidemiological studies tend to present themselves in a favourable light and therefore over- or under-report measures such as physical activity, smoking and alcohol consumption. This is especially relevant with physical activity, which is believed to be at considerable risk of information bias. Still, the physical activity questionnaire used in HUNT3, which were also used in HUNT2, has, through a validation study, been found to provide an adequate measure of leisure-time physical activity in men (women were not included in the study), especially in the category of ‘vigorous physical activity’ (Kurtze et al., 2007).

Misclassification of outcome

The outcome in this study is self-rated general health, which is a widely studied and validated health measure (DeSalvo et al., 2006; Fosse & Haas, 2009; Schnittker & Bacak, 2014). As stated above, self-reporting is susceptible to reporting bias, and one can assume systematic differences in health reporting between age groups, sexes and socioeconomic positions.

Studies have reported mixed findings on gender differences in the validity of self-rated health, revealing greater predictive validity among both men (Manderbacka et al., 2003) and women (Baćak & Ólafsdóttir, 2017) as well as no differences between the genders (Zajacova et al., 2017). Regarding age, self-rated health has been found to better predict mortality at younger ages (Burström & Fredlund, 2001; Zajacova & Woo, 2016). Health is found to vary between education levels at the same level of self-rated health, especially at higher levels of self-rated health. Generally, respondents with more education had healthier levels of biomarkers at the same level of self-rated health compared with respondents with less education (Dowd & Zajacova, 2010).

Considering the purpose of this study, we trust the validity of self-rated health. Additionally, self-rated health was originally a four-category variable that was dichotomised into ‘good’ and ‘poor’ health in the analyses. This can reduce the risk of misclassification due to socioeconomic differences between higher levels of health.

Confounding

A confounder is a variable that influences both the outcome and exposure; a confounder must be an extraneous risk factor for the outcome of the study and must also be associated with the exposure (Rothman, 2012; Rothman et al., 2021). A variable that is affected by the outcome and the exposure is a *collider,* whereas a variable on a path between the predictor and outcome is a *mediator*. Figure 4 illustrates these three scenarios.

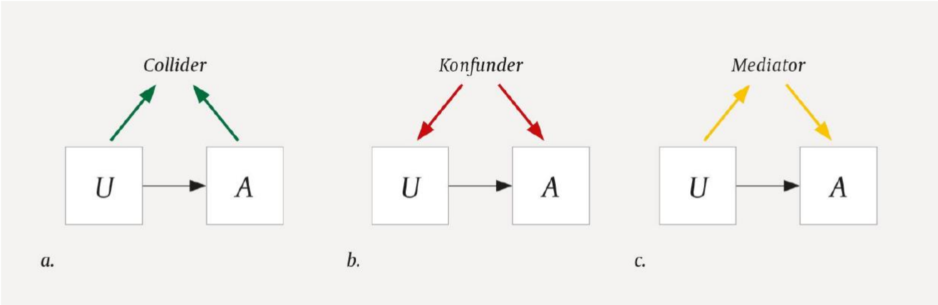

Figure 4: *Illustration of a collider, confounder and mediator (Jo Røislien (2021). Trekantdrama. Tidsskrift for legeforeningen).*

Confounding is a common methodological challenge in social epidemiology. By overlooking or excluding important confounders in analyses, one risks drawing false conclusions about the association between an exposure and an outcome. A collider should not be adjusted for, nor should a mediator if the researcher is interested in the total effect of an exposure on an outcome.

Strictly speaking, confounding is a phenomenon in studies that investigate causal relationships between a main variable of interest and an outcome (Conroy & Murray, 2020; Norvell, 2011). In this dissertation, the aim is not to argue for a causal relationship between geographic affiliation and levels of self-rated health. Therefore, confounding is not a major methodological concern in our analyses. Attempting to control for confounding factors in descriptive analyses may produce incorrect results, as it may accidentally open a collider path and create a false association (Conroy & Murray, 2020; Hernán & Robins, 2020). In this study, we could not, with certainty, identify factors that influenced both geographical residency and self-rated health without being affected by geographical affiliation. Nevertheless, we wished to control for differences between the rural coastal population and the other populations in order to obtain comparability between areas. The main concern was that the geographical groups differed from one another in some variables that are related to the outcome self-rated health. In the analyses, we therefore chose to include age and sex as covariates in all three papers.

Missing data

Missing data can introduce bias in the estimations. The primary types of missing data are missing completely at random (MCAR), missing at random (MAR) and missing not at random (MNAR) (Enders, 2022). In Paper I, we included many covariates in the analyses. The proportion of missing data varied significantly between variables; for example, behavioural and psychosocial factors generally had high levels of missing values at approximately 20%. Missing values on these types of variables can potentially be missing not at random due to unwillingness to answer such questions. However, the missing values on these variables can be because many of these questions were asked in the second questionnaire which fewer participants answered.

Missing data were handled through full information maximum likelihood (FIML) in Paper I and through multiple imputation in Paper III. FIML is acknowledged as an adequate alternative to multiple imputation in managing missing data (Peyre et al., 2011). The estimations obtained from imputed data in Papers I and III did not differ substantially from the estimations for complete case data, which indicates that no substantial bias was caused by missing data. In Paper II, only complete cases were included in analyses. The proportion of missing data was small and therefore unlikely to introduce bias.

6.2.2.2 External validity

External validity, also referred to as generalisability, is the transferability of inferences to populations outside the source population. As described previously, the area and population of the former Nord-Trøndelag County is considered to be representative of the overall Norwegian population. It should be noted that the area lacks larger cities, and the education and income levels are slightly lower than the national average (Krokstad & Knudtsen, 2011; SSB, 2020). The trends in health and mortality in the area are found to generally follow national trends, with some variations from the national average (Krokstad & Knudtsen, 2011). Socioeconomic health differences in the Nord-Trøndelag population have been reported as somewhat lower than national levels and align with findings from European countries (Krokstad et al., 2002). The large number of participants and the high participation rates likely strengthen the external validity of the findings.

However, the generalisability of the findings to other coastal areas is perhaps somewhat limited. Rural coastal areas of Norway have been subject to several government-instigated processes and investments that are likely unique to the area, both on an international and European scale. I consider the external validity to be strong within the Norwegian and perhaps Nordic context, but differences in welfare support and public investments in rural areas should be considered in comparisons with findings from other areas of the world.

6.3 Interpretations of main findings

Norway has a long-standing history of fishing, especially small-scale fishing. The industry's decline in the latter half of the 20th century deeply affected many coastal communities. Concurrent with its decline, several larger restructuring processes transpired in Norway. Norway has been through an extensive investment in the public sector, which produced new employment opportunities that have been especially important in the upholding of rural communities. There has been a substantial strengthening of welfare services and an overall increase in the population's educational level, with women increasingly entering the labour market. Geographical settlement patterns have changed due to urbanisation but have become somewhat consolidated into settlements that are evident to date. Aquaculture has emerged as a new coastal-based industry, providing opportunities for employment and income in many rural coastal areas.

In this setting, we examined the health of a Norwegian rural coastal population. We studied developments in population health in a coastal area with a history of small-scale fishing, and findings were compared with surrounding areas. Our classification of rural coastal municipalities, based on historical employment in fishing, provides a new definition of coastal populations that captures the heterogeneity within coastal settlements. In the following, our findings are compared with existing literature, and some possible causes of the findings are discussed.

6.3.1 Comparisons with existing literature

To my knowledge, the current study is the first to assess health in coastal areas during a period of societal restructuring. Therefore, the opportunities for direct comparisons with similar studies are limited. Still, as defined in the introduction, this study is in its essence a study on geographical disparities in health over time, and in the following section, I place the findings in the context of existing literature regarding coastal health and geographical as well as social disparities in health.

6.3.1.1 The health of coastal populations

The key finding throughout Papers I–III is that self-rated health in this rural coastal population, despite improving, remains generally poorer compared with populations from the urban coast, rural inland and rural fjord. In Paper I, we demonstrate that greater odds of reporting poor self-rated health in the rural coastal population remained after controlling for several behavioural, employment and psychosocial factors. Across the decades of data collection, the age- and gender-adjusted prevalence of poor self-rated health was found to be the largest in rural coastal areas in both adults and elderly compared with those in adjacent areas.

Caution should be exercised when comparing these findings with those from existing studies. I am not aware of existing literature with similar methodological design and aims, so the foundation of direct comparisons with previous studies is limited. Population statistics for both Norway and the UK have found the coastal population to generally exhibit poorer health than inland populations (Office for National Statistics, 2014; Aase, 1996). Nevertheless, studies on coastal health in the UK have reported a positive association between health and proximity to the coast when controlling for relevant individual- or area-level covariates (Wheeler et al., 2012; White et al., 2013). This was not the case in the current study, as poorer rural coastal health remained after controlling for a list of several covariates. Some aspects of the current study can aid in explaining the contrasting results between these findings and those of previous studies.

First, and perhaps most importantly, the classification of the coastal population in the majority of previous studies has been based on different criteria than in our papers. The previous studies, which are outlined in the background chapter, have generally assessed potential health effects of living in close proximity to the coast, whether that be living with a view of the coast, the indirect effects of coastal living through outdoor activity or the exposure to coastal-specific pathogens. In other words, existing literature on coastal health has used a classification of the coastal population that is primarily based on *proximity* to the coastline. This has been a fruitful study population classification for the purposes of previous studies, but this classification obscures nuances and heterogeneity in the coastal population regarding the amount of societal involvement with the surrounding coast. To my knowledge, this study is the first to introduce a coastal classification based on the population's level of employment in a coastal industry. With the new classification in this study, we assessed differences in health situations within the coastal population. The findings in Papers I–III reveal differing health situations between the four geographical categories, although three of the geographic categories can be classified as coastal if the classification is based on having a physical connection to the coast. This illuminates the health heterogeneity within coastal areas. In the landscape of research on coastal health, this thesis therefore provides additional nuances to the knowledge of coastal health.

Nevertheless, the methodical discrepancy between the current and previous studies offers results that are not necessarily comparable.

Second, previous studies that have controlled for different covariates were conducted with data from the UK (Wheeler et al., 2012; White et al., 2013). It is reasonable to anticipate that coastal settlements in Norway differ from those in the UK in several aspects. Norway's policies support rural settlements, offer considerable welfare generosity and investments in new coastal-based industries. Findings from the UK indicate lower employment rates in coastal areas and reveal that coastal employment tends to involve low-skilled and seasonal labour (Depledge et al., 2017). Additionally, concerns have been raised that many potential marine technology growth sectors are not based in coastal areas (Morrissey, 2017). This challenges comparisons of our findings with existing studies.

6.3.1.2 Rural-urban disparities in health

In this thesis, findings from the three papers reveal differing health situations between urban and rural areas, and perhaps most importantly, between rural and urban coastal areas. Rural coastal areas exhibit poorer self-rated health across all decades compared with urban coastal areas. In Paper I, we reported significantly poorer self-rated health in both rural coast and rural fjord populations than in the urban coastal populations. The rural inland population did not differ significantly in self-rated health from the urban coastal population. In existing literature, rural-urban health disparities are thoroughly documented; the same is true in Norway. Therefore, health disparities between rural and urban areas in this study population were anticipated. Findings in existing literature differ between studies and regions, but in Norway, both mortality rates (Bremberg, 2020) and poor self-rated health (SSB, 2019c) have been found to be higher in less densely populated areas. The findings are therefore consistent with Norwegian literature.

The geographical classification used in this study revealed differences in self-rated health not only between rural and urban areas but also between different rural areas. In Paper I, non-overlapping confidence intervals between rural coast and rural fjord populations indicated differences in self-rated health between these groups, with the rural coastal population exhibiting the poorest health. In other words, rural coastal areas with a history of small-scale fishing and general involvement in the surrounding water exhibited poorer health than those in similar rural areas with little or no coastal involvement through fishing. This demonstrates that these two rural populations in this region, despite sharing the characteristic of having water and coast nearby, differ somewhat in overall health. Rural fjord inhabitants have historically been more dependent upon farming as a primary sector. Farming has, similar to small-scale fishing, undergone a great transformation, including a substantial decrease in the number of farms and farmers (Torske, 2017). Therefore, rural fjord inhabitants, similar to rural coastal residents, have experienced a decline in a crucial source of employment. However, as farming is a widespread livelihood across most rural areas in this Norwegian context, changes in this industry have likely affected population health in all rural areas somewhat equally.

The findings therefore bring further knowledge and nuances to the perspectives on the rural-urban dichotomy in health. As described in the background chapter, rural-urban health disparities do not necessarily constitute a clear divide between rural and urban areas. Curtis (2004) emphasises that a sharp distinction can cover up localised pockets of rural health deprivations, causing an underestimation of their significance. In this thesis, by distinguishing between rural areas, we found geographical disparities that otherwise may have been covered up using other classifications. Existing literature has also revealed that rural-urban health disparities are a gradient rather than a divide, and this gradient is also evident within categories of urbanity and rurality (Eberhardt & Pamuk, 2004). In the analyses, the geographical classification does not provide information on the degree of urbanity and rurality, and we therefore cannot specify a health gradient on a continuum in this study population. It should also be noted that areas classified as urban in this study would not necessarily be classified as urban in the context of other countries or regions. We classified all towns as urban, but they probably do not represent true urban spaces in which more finely grained divisions, such as zip codes, can provide adequate predictors of health.

6.3.1.3 Contextual and compositional factors

This thesis reveals that poorer health in rural coastal areas persists both over time and when controlling for a list of potential contributing factors. In Paper I, the analyses on data from HUNT3 included several covariates that represented employment, behavioural or psychosocial factors. Results from these analyses indicated that behavioural factors seem to contribute most to the association between living in rural coastal areas and reporting poor self-rated health, which are closely followed by employment factors. Consistent with literature on geographical health disparities (Diez-Roux, 1998; Macintyre et al., 2002; Subramanian et al., 2003), this indicates that some of the observed differences in self-rated health between those in rural coastal areas and urban coastal areas are due to *compositional* factors associated with individual traits of inhabitants.

However, analyses in Paper I also revealed that the majority of the association between geographical affiliation and self-rated health remained unexplained after controlling for all covariates. This was somewhat unexpected, as previous studies have suggested that little geographical variance in health remains after controlling for compositional factors (Duncan et al., 1993; Fogelholm et al., 2006). Based on our findings, one cannot conclude whether the unexplained association is attributable to compositional or contextual factors or both. Nonetheless, it is notable that the majority of the association remained after controlling for a long list of individual-level factors. Potential contextual factors are therefore not eliminated in the association between living in rural coastal areas and the odds of reporting poor health.

Nevertheless, as Macintyre et al. (2002) emphasise, describing context as a residual category after controlling for factors that were perceived as compositional may cause the researcher to ignore the potential intertwinement between level effects. There is no straightforward distinction between compositional and contextual effects, as they can be intertwined and are often applicable to both individual and structural levels. In Paper I, although neither causality nor pathways are proven, the results indicated an indirect contribution of behavioural factors through employment factors. This suggests that lifestyle behaviour can be connected to the employment situations of rural coastal inhabitants. Historically, coastal-related occupations, such as fishing, have been found to be associated with poor lifestyle choices. This especially includes smoking and alcohol consumption (Koren, 2017; Thorvaldsen et al., 2016). Paper I reveals a higher prevalence of smoking in the rural coastal population than in adjacent areas. Therefore, as depicted in literature on compositional and contextual factors (Diez-Roux, 1998; Shaw et al., 2002), individual traits of rural coastal inhabitants may potentially be intertwined with larger-scale structures, such as employment patterns and culture in the fishing industry. However, as this study’s methodological design do not detect causality, this remains speculation.

6.3.1.4 Social health inequalities and societal restructuring

Considering the well-established socioeconomic gradient in health, as well as the potential vulnerability of some social groups to the societal restructuring seen in coastal communities, we examined rural coastal trends in self-rated health in a socio-economic context. We used two different measures of inequalities in health: absolute and relative inequalities in health. Using education as a proxy for socio-economic position, Paper III reveals that relative social inequalities in self-rated health have decreased steadily across the period of the HUNT Study in the rural coastal population. Compared to trends in adjacent areas, the development of relative educational inequalities in self-rated health was more favourable in the rural coastal population compared with the urban coastal and rural fjord populations in which relative health inequalities remained the same or increased, respectively. For absolute educational health inequalities, the rural coastal population exhibited an increase from HUNT1 to HUNT2, which was followed by a stable decline through HUNT4. Despite the temporal increase, also trends in absolute inequalities in self-rated health were more favourable in the rural coastal population compared with adjacent areas.

The findings for the rural coastal population contrast with overall findings for European data after the millennium, as reported by Mackenbach et al. (2018), which reveal increasing relative and absolute educational inequalities in self-assessed health between 2002 and 2014. This discrepancy is also apparent when comparing this study's findings with combined data from 17 European countries gathered between 1990 and 2010, which demonstrates increasing relative and stable absolute socioeconomic inequalities in self-assessed health (Hu et al., 2016). The findings herein also contrast with Norwegian data on mortality, which reveals increasing relative educational inequalities in total mortality from 1960 to 2010 (Strand et al., 2014).

A key focus in this thesis is the aspect of restructuring; hereunder how health and social inequalities in health have developed throughout societal changes. Comparisons with existing literature are challenging. The existing literature on trends in self-rated health during societal change is somewhat limited, and the majority of studies are conducted against the backdrop of larger economic recessions. Nevertheless, some general observations can be made.

First, the findings for this rural coastal population reveal an improvement in self-rated health during a period characterised by substantial restructuring in the local labour market. Moreover, this improvement was larger compared with adjacent areas that did not undergo similar restructuring in a local industry. Compared with existing literature that reports deteriorating self-rated health during times of recession (Abebe et al., 2016; Nettleton & Burrows, 1998; Zavras et al., 2013), our findings contrast. Although the period of HUNT1–HUNT4 (1984–

2019) cannot necessarily be referred to as an economic recession in the rural coastal areas, the processes likely share some characteristics.

Second, as mentioned, our findings reveal that relative social inequalities in self-rated health have narrowed in the rural coastal population during this period. This contrasts with several studies that report increased health inequalities during periods of crisis (Bacigalupe & Escolar-Pujolar, 2014). Our findings also contrast with studies on Nordic countries that reveal stable inequalities in health during the economic recession in the 1980s and 1990s (Lahelma et al., 2002). Hence, our findings overall do not align with trends in health inequalities reported in the majority of studies. Still, comparisons should be made with caution, as the timespan of the HUNT Study or preceding decades do not necessarily represent a period of severe crisis or recession, despite substantial restructuring.

6.3.2 Possible causes of our findings

6.3.2.1 The perspective of restructuring

Overall, our findings suggest health improvements in rural coastal areas between the 1980s and 2020. In Paper II, we find that the prevalence of poor self-rated health decreased in rural coastal areas in adults and elderly people. The findings reveal that this is also the trend in residents of adjacent areas, but the rural coastal population exhibited the greatest decrease in poor health in adults compared with those in remaining areas. Decreasing marginal effects indicate smaller health differences between rural coastal areas and remaining areas over time. In other words, geographical health disparities between rural coastal areas and the remaining areas have narrowed in the adult and elderly population in this study population.

The main aim of this thesis is to study health developments in a rural coastal population against the backdrop of a substantial societal restructuring. The observed health improvements in the rural coastal population can be interpreted in light of Aase's (1993) perspective of restructuring. As described previously, Aase emphasises that large structural changes in a society can affect the overall health level of its population, as new cohorts are confronted with different health risks than their predecessors. From a generational perspective, we find in Paper II that adults and elderly people have improved their self-rated health substantially between the first and the fourth HUNT survey. This suggests that the restructuring of rural coastal communities may have resulted in new generations living lives that involve fewer health hazards than their preceding generations of parents and grandparents.

Societal restructuring can affect the health of inhabitants through both positional and structural effects (Aase, 1993). Improvements in the health of the rural coastal population can be interpreted as a combination of such effects.

Positional effects involve health improvements within a specific group. In the rural coastal context, occupations in fishing have undergone a substantial improvement in working conditions. Historically, occupations in small-scale fishing were considered hazardous, as they offered greater risks of both injuries and fatality and were combined with poor lifestyle habits. The current fishing fleet offers more technologically sophisticated vessels with safer fishing gear, and working conditions on board are considered safer compared to former working conditions in traditional small-scale fishing (Thorvaldsen, 2015; Thorvaldsen et al., 2018). Therefore, workers in the current fishing fleet likely enjoy better health. Considering the findings from Paper II, compared to previous generations, the current working-age coastal population probably face different working conditions, and the current elderly coastal population probably hold different working experiences.

Findings from Paper III provide some support to the assumption of improved health in certain occupational groups. Although our results reveal a *stable* age-standardised prevalence of poor self-rated health in inhabitants with primary education (historically, employment in fishing required little or no formal education), this does not disprove the existence of a positional effect. Considering that we observed narrowing educational inequalities, in contrast to national and European trends, the positional effect of improved working conditions for fishers may have mitigated or stabilised increased educational inequalities. Reduced differences in working conditions between educational groups have likely contributed to reduced health differences in said groups.

Positional effects within the fishing industry have likely been accompanied by substantial structural effects. In combination, the major decline in small-scale fishing employment, the investment in the public sector and the emergence of aquaculture have caused considerable shifts between occupations in the rural coastal population. New generations of rural inhabitants are likely confronted with improved employment opportunities and conditions compared to former generations. A general shift from fishing to employment in the public sector or in aquaculture has likely entailed an overall reduction in occupation-related health hazards in the rural coastal population. The observed health improvements in the total rural coastal population can therefore also be interpreted as structural effects that occurred simultaneously with positional effects in certain groups.

6.3.2.2 Other perspectives on population health changes

As stated previously, Aase (1993) emphasises that processes of population health changes are often intertwined and therefore challenging to isolate. Therefore, health changes that are interpreted as results of restructuring can also be caused by concurrent processes, potentially strengthening or mitigating health effects produced by societal restructuring. The improvement in working conditions in the fishing industry can, as mentioned, be interpreted as a positional effect within a specific group, but it can also be interpreted as an effect of the strengthening of the working environment legislation introduced in the 1970s. The Working Environment Act of 1977 was a substantial revision of former employment legislations, and aimed to ensure sound working conditions and to prevent adverse effects of the working environment on physical and psychological health (Ellingsæter et al., 2020). With this development in working safety, the positional effect of improved fishing safety can also be interpreted as a result of an *intervention*. Similarly, the surge in the education level in Norway after the mid-20th century, which was also evident in rural areas, may have reinforced the process of *diffusion* (Rogers, 2003). With an overall higher level of education across Norwegian regions, the variations and delays in adopting new lifestyle habits and health innovations may have been reduced. Relatedly, the expansion in information technology in the latter half of the 20th century likely ensured the somewhat equal distribution speed of health innovations across geographical areas.

Migration should also be considered when interpreting these findings, as it is closely connected to the greater societal developments discussed thus far and can be viewed as a restructuring process. Migration does, in some circumstances, involve shifts in a population’s composition and can therefore in such instances be interpreted as a *structural effect*. Many Norwegian coastal communities have experienced significant outmigration in the years of urbanisation, which began in the post-war era (NOU 2020: 15), and some areas have been completely vacated. Some rural coastal inhabitants may have chosen to out-migrate when livelihoods were lost, as other areas could provide employment opportunities. Studies on selective migration have found that selective migrants exhibit better health (Riva et al., 2011), so one can assume that people of a certain health level had the opportunity and chose to leave rural coastal areas. Therefore, the outmigration may have resulted in a remaining rural coastal population who exhibited somewhat poorer health, which potentially contributed to the poor starting point in self-rated health in rural coastal areas in HUNT1. The larger waves of outmigration occurred before and during the first surveys in the HUNT Study. Hence, there is no foundation for comparison with the rural coastal population preceding this shift. Nevertheless, we observe improving rural coastal health since the 1980s and throughout the course of the HUNT surveys. In this period, migration patterns have largely settled, and migrants entering the rural coastal study area, such as migrant workers, are limited (IMDi, 2021). Thus, we can to some extent assume that the observed improvement in rural coastal health was likely not caused by migration of healthy inhabitants to and from the area.

6.3.2.3 The welfare state and public sector investments

As emphasised in the background chapter, Nordic welfare regimes are assumed to buffer against the adverse effects of economic recession and societal restructuring (Abebe et al., 2016). Our findings reveal improvements in self-rated health across decades in adults and elderly people in all geographical categories in this study, with rural coastal inhabitants generally exhibiting the most favourable developments. In Norway, welfare schemes have been considerably and continuously strengthened since the National Insurance Act of 1966 (Ellingsæter et al., 2020), which was combined with extensive national spending on both welfare services and public sector investments in the 1970s and 1980s (Mørk, 1984). The findings reveal that self-rated health has improved more greatly in the rural coastal population compared with those in adjacent areas, despite the area losing a crucial industry. This may indicate that strong welfare services and new employment opportunities in the public sector may have mitigated the potentially adverse health effects of industrial decline.

To summarise the discussion of the findings' possible causes, several concurrent societal processes can shed light on the improvements in rural coastal health. This study's design does not provide proof of causality between these processes and developments in population health, and I can only describe the observed developments in light of possible explanations. These processes are likely intertwined, and one can assume that they have reinforced one another to some extent. These processes are also part of larger-scale developments that extend beyond the population of this study. Bambra et al. (2019) emphasise the benefit of "scaling up" when analysing geographical inequalities in health, as macro political and economic structures often constitute important drivers behind place-based health inequalities. Although causality is not proven between these processes of restructuring and developments in health, the processes and their interplay should not be dismissed as potential influences on population health.

6.4 Implications and future perspectives

Developments in population health during societal restructuring is a subject of interest in social epidemiology. In this thesis, health developments in a Norwegian rural coastal population were studied utilising data from the HUNT Study, from the 1980s to 2020. Norwegian rural coastal areas have undergone considerable processes of restructuring related to the decline in small-scale fishing, extensive public sector investments, outmigration and new utilisation of coastal resources, among other changes. Our findings reveal that the rural coastal population of the former Nord-Trøndelag County in Norway exhibited worse levels of self-rated health compared with those in adjacent areas across the HUNT surveys. Nevertheless, the rural coastal population exhibited an improvement in levels of self-rated health, and a decrease in relative educational inequalities in self-rated health during the same period.

Overall, our findings provide no evidence of adverse health effects on the population caused by the societal restructuring in rural coastal areas in the latter half of the 20th century. This brings nuances to the existing knowledge of changes in population health during societal restructuring and industrial decline. The methodological design does not provide evidence of causality between larger societal processes and health developments, although the setting of a Nordic welfare state regime and extensive investments in public sector employment is evident. The findings emphasise the plausible importance of these factors in mitigating adverse population health effects from restructuring and declining industries. A welfare safety net and alternative employment can be of crucial importance to population health during and following substantial restructuring. Alternative employment is also likely to enable healthy individuals to remain in the area. The new utilisation of ocean resources through aquaculture should also be mentioned. This has provided many rural coastal areas with a location-specific industry, which supports the upholding of population and provides income to the municipalities and their residents.

Considering the findings in this study, notions regarding population health after industrial declines should perhaps be more nuanced. These findings can, in sum, indicate that a society is not completely powerless in their encounters with failing industries and the subsequent risks posed to population health. Nonetheless, there may be policy implications that were not discovered in this study. Suhrcke and Stuckler (2012) emphasise that studying developments in population averages during times of societal restructuring may conceal differing responses to restructuring across population subgroups. Therefore, these findings should not be interpreted to mean that no further action is needed to counter potential worsening of population health during societal changes, as specific groups may still be at an increased risk of the unfavourable health effects of restructuring.

6.4.1 Future perspectives

In this thesis, the health of a coastal population was assessed against the backdrop of larger societal restructurings. Norwegian coastal areas are unique in several aspects: the nation supports the upholding of these rural settlements (Berg & Lysgård, 2002), the residents enjoy one of the world's most generous welfare regimes in which health services are distributed across the country (Ellingsæter et al., 2020) and the inhabitants benefit from investments in new coastal-based industries such as aquaculture (Food and Agricultural Organization of the United Nations, 2018). These traits of the study area should be emphasised, and generalisations of the findings to other populations, both internationally and in Europe, should be made with caution. Therefore, future research could benefit from assessing similar research questions in coastal areas that do not share these traits. This can provide valuable foundations for comparisons that could illuminate the magnitude of such traits to health developments during societal restructuring.

In this thesis, health changes were assessed in population averages. To extend the problematisation by Suhrcke and Stuckler (2012), future studies could benefit from greater focus on health developments in certain subgroups of the population to assess potentially vulnerable groups during societal restructuring. Such groups could be employees who are directly affected by industrial decline, such as fishing employees. This could also include migrant workers, who were not studied specifically in this thesis. The rural coastal area in this study has a lower portion of migrant workers compared with other fish-farming municipalities in Central Norway (IMDi, 2021), and future studies that focus on the health of this group of coastal inhabitants could provide insights into potential health inequalities that were not detectable with the current study design.

Furthermore, the limitations of the current descriptive study design should encourage future research to assess similar research questions through methods better suited to examine causal relationships between coastal living and developments in health. Moreover, the benefits of multilevel modelling can be utilised. Multilevel modelling is frequently used in studies of spatial disparities in health and can provide insights on variations at both the individual and society levels.

This study was based on quantitative methods, and findings captured developments in self-rated health on an aggregated level over time. Consequently, the personal perspectives and experiences of coastal inhabitants during the coastal restructuring were not illuminated. The findings reveal that new generations of coastal adults and elderly people exhibited better health compared with preceding generations. Moreover, a finding not discussed thoroughly in this thesis is the considerable worsening in youth health in all geographical areas of this study population. A recent study conducted in the same county as this thesis revealed a strong increase in anxiety and depression symptoms among adolescents in the period between the third and fourth HUNT survey (Krokstad et al., 2022). Growing up in rural coastal areas are likely to entail completely different life courses than earlier generations. Qualitative studies on the generational experiences of this restructuring are currently being conducted in Norwegian coastal areas through the interdisciplinary mother project of this thesis: ‘Norway as a Sea Nation’.

7 Conclusions

This dissertation examined the health situation and decennial health trends in a Norwegian rural coastal population. The rural coastal area in this study has been characterised by significant societal restructuring since the decline in small-scale fishing. Our findings reveal that the rural coastal population exhibited poorer health compared with adjacent areas across four decades. Nonetheless, the findings reveal that the health of this rural coastal population has improved and that health gaps between the areas have narrowed. Moreover, educational inequalities have decreased in this rural coastal population, which is counter to European trends. Together, the findings demonstrate that health and health inequalities have improved during times of societal restructuring.

Although one cannot attribute this improvement in rural coastal health to specific restructuring processes, the substantial shift from small-scale fishing to alternative employment opportunities has likely improved the general working conditions for many inhabitants in these areas.

Our findings reveal that populations in close proximity to the coast exhibit differing health levels. The observed differences in health between rural coast and rural fjord populations in this study emphasise the heterogeneity within coastal populations and therefore offer nuances to existing literature on coastal health. More research is needed regarding health disparities within populations in close proximity to the coast.

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Paper I-III

Paper I

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Understanding coastal public health: Employment, behavioural and psychosocial factors associated with geographical inequalities. The HUNT study, Norway

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ABSTRACT

Recent decades have shown an international trend of decline in small-scale fishing; a longstanding and vital industry for numerous coastal populations. The decline has resulted in a loss of livelihoods in many coastal communities, potentially afflicting public health. Still, knowledge about the health situation of these areas is limited. Former studies on coastal health have primarily defined coastal areas based solely on their proximity to the coast, therefore not targeting the traditional coastal communities with longstanding coastal involvement through small-scale fishing. In this paper, we aim to illuminate the health situation in these areas by introducing a more fine-grained classification of the coastal study population; considering both geographical proximity to the coast, population density and employment in fishing. Using data from the Norwegian population-based HUNT Study, we perform individual and simultaneous adjustments for employment, behavioural and psychosocial factors to assess the contributions of these factors to the association between geographical affiliation and self-rated general health. The rural coastal areas with a history of small-scale fishing show a poorer health situation compared to urban coastal, rural inland and rural fjord populations, and behavioural factors contribute the most to the observed health disparities. Our findings encourage greater focus on societal differences between coastal communities when studying coastal health.

1. Introduction

Population statistics of England, Wales and Norway reveal populations of coastal areas to be more likely to report poor health compared to inland populations (ONS, 2014; Aase, 1996). Coastal areas, which are extensive and heterogeneous regions, have been of substantial historical and economic importance to numerous nations; inhabiting vital and bearing industries ranging from long traditions of small-scale fishing and shipping to recent upscale fisheries, fish farming and oil exploration (Hundstad, 2014; Urquhart et al., 2011; Johnson et al., 2012). However, recent decades have shown an international trend of considerable decline in small-scale fishing, a long-standing and widespread coastal industry tightly entangled with both social and economic relations of coastal communities (Johnson et al., 2018; Urquhart et al., 2011). This decline is also apparent in Norway, a sea nation where many coastal communities, often rural, have faced major drops in fish stocks from the mid twentieth century, some places combined with booming new industries of oil and fish farming (Onsager et al., 2015; Christensen and Zachariassen, 2014). Many coastal communities have experienced loss of livelihoods and outmigration, and not all have transitioned to new coastal industries (Iversen et al., 2020). Considering the well-established association between area characteristics and several health outcomes, and the intertwinement of public health and economic and social changes operating over decades (Pickett and Pearl, 2001; Men et al., 2003; Hanlon and McCartney, 2008), the downturn in small-scale fishing might compromise the health of coastal populations.

Existing literature on coastal health provides valuable insights about potential health effects of both biological aspects of marine life (Stewart

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et al., 2008) and physical proximity to coastal areas and bluespaces (Wheeler et al., 2012; White et al., 2013; Garrett et al., 2019; Pasanen et al., 2019). However, there is limited attention on the health situation of coastal areas historically characterized by small-scale fishing and long-standing involvement in the surrounding coast, and how these areas might differ from other coastal-adjacent areas. In this study, we aim to assess the health situation of rural coastal areas with a history of coastal involvement, with an emphasis on the contribution of employment, behavioural and psychosocial factors.

1.1. Defining the coastal population

Existing research on coastal health, while providing knowledge about coastal living and health, shares two delimiting traits preventing further insight into the health situation of coastal areas with a history of small-scale fishing. Firstly, and importantly, the definition of coastal populations in former studies is mainly based on proximity to the coast without further consideration to variations in demography and coastal involvement. Considering that coastal areas can be characterized as extensive and heterogeneous regions (Neumann et al., 2015), a geographical classification based solely on coastal proximity risks covering up potential health variations within the coastal population itself. This can include health variations between urban and rural areas (Eberheardt and Pamuk, 2004). This aspect is scarcely assessed in coastal health, but captured by Wheeler et al. (2012) through their urban-rural stratified analyses on health effects of coastal living. However, a mere urban-rural classification of the coastal population does not consider the distinction of coastal communities with or without coastal-involved industries and employment, thus providing limited insight into the health situation of coastal settlements with a tradition of small-scale fishing compared to other coastal and non-coastal areas (Urquhart et al., 2011).

Therefore, we propose a more fine-grained classification of coastal areas, which could aid in capturing the hypothesised heterogeneity of the coastal population. In addition to a distinction between rural and urban coastal areas, as seen in Wheeler et al. (2012), we propose a further classification of the rural coastal areas based on coastal-involved industries. This entails including a rural aquatic coastal category, consisting of rural coastal areas with a history of small-scale fishing. As the loss of livelihoods in these areas may pose potential population health hazards differing from other coastal-adjacent areas without the same coastal industry involvement, a distinction between traditional rural coastal-based areas and other coastal areas might be fruitful when assessing coastal public health.

1.2. Context and composition in coastal health

In addition to a largely proximity-based approach in defining the coastal population, the majority of existing research on coastal health is heavily revolved around *contextual* aspects of geographical inequalities in health; focusing on how physical traits and closeness of the coast itself affects health. Contextual factors often appear as obvious explanations for geographical dispersion of health (Shaw et al., 2002), yet, they are often mediated and heavily intertwined with the composition of the population, including individual traits of the inhabitants (Shaw et al., 2002; Diez-Roux, 1998; Macintyre et al., 2002). In addition, studies suggest that little geographical variance in health remains after controlling for compositional factors (Duncan et al., 1993; Fogelholm et al., 2006). Some studies on coastal health have substantiated the importance of compositional factors by revealing a positive association between coastal proximity and health after controlling for both potential area and individual level confounders (Wheeler et al., 2012; White et al., 2013; Garrett et al., 2019). These findings contradict population statistics showing higher prevalence of poor health in coastal populations compared to inland populations (ONS, 2014; Aase, 1996), therefore implying that poor coastal health could be related to the composition and traits of the coastal population.

Still, these studies have not primarily targeted the *relative* contribution of compositional predictors. In the field of social inequalities of health, several studies have investigated mechanisms underlying the social gradient of health, revealing both individual and combined effects of numerous predictors of health, such as material, behavioural, psychosocial and biomedical factors (Skalická et al., 2009; van Oort et al., 2005). Here, the literature of geographical inequalities of health, and hereunder also coastal health, is limited in exploring the relative contribution of relevant health predictors. This leaves uncertainty of potential compositional mechanisms underlying the association between coastal proximity and health. In this paper, we examine the relative contributions of employment, behavioural and psychosocial factors in coastal health - three potentially intertwined factors.

Understanding the contribution of employment factors may be crucial when assessing coastal health. In Norway, the decline in small-scale fishing has affected many workers and their families (Onsager et al., 2015; Hundstad, 2014). Older inhabitants may have experienced this decline first-hand through loss of work and livelihood for themselves or their family provider. By extension, the failure of a bearing industry and the subsequent unemployment and outmigration may have reached further than the directly inflicted employees and families. Considering that health risks of area characteristics are found to afflict differently according to occupational class (Pickett and Pearl, 2001), some groups may be more vulnerable to the societal restructuring of coastal communities. Moreover, potential health hazards of coastal occupations should be considered. The fishing industry involves greater physical burdens and hardship compared to other occupations, despite fishers reporting good health and high job satisfaction (Thorvaldsen et al., 2016). Therefore, both current and former employees of the primary sector in coastal areas may have been exposed to health risks through their profession. Nevertheless, emerging industries of oil and aquaculture (Giskeødegård, 2014) may provide new occupational opportunities and lessened health hazards in coastal occupations.

Following employment factors, we also aim to examine the contribution of behavioural and psychosocial factors to coastal health. Occupations within the fishing industry are found to be related to behavioural factors such as poor lifestyle habits, including a history of great alcohol intake in the Norwegian fishing culture (Koren, 2017), in addition to a higher prevalence of smoking in fishers in several European countries, including Norway (Matheson et al., 2001; Thorvaldsen et al., 2016). Additionally, behavioural factors may also be related to the societal changes of the rural Norwegian coastal areas, as unemployment and social disintegration might induce habits of health risk behaviours (Men et al., 2003). Relatedly, the restructuring of coastal industries may affect the psychosocial health of the population. The traditional involvement of the whole family in the day to day life, in addition to the flat and democratic structure of many coastal communities, has been challenged (Johansen, 2014; Hundstad, 2014), potentially resulting in lessened reliance and social interaction between inhabitants and a subsequent social disintegration. In all, compositional factors related to the employment, lifestyle and psychosocial surroundings of coastal areas might be of crucial importance in understanding coastal public health.

In this study, using population health data from Norwegian coastal and inland municipalities, we aim to deepen the understanding of public health in areas with a tradition of small-scale fishing. By introducing a more fine-grained definition of coastal populations, based on rurality and historical coastal involvement, we want to compare the health situation of traditional rural coastal areas to other coastal-adjacent areas, as well as to inland areas. By stepwise and simultaneous adjustment for employment, behavioural and psychosocial factors, we will assess the relative contributions of these factors to the association between geographical affiliation and self-rated general health; subsequently comparing underlying compositional mechanisms of rural coastal health to other areas.

2. Methods

2.1. Data

We based our study on data from the third round of the total adult population-based cross-sectional Nord-Trøndelag Health Study (HUNT3, 2006–2008) (Krokstad et al., 2013). The HUNT Study is conducted in the now former county of Nord-Trøndelag, Norway, which consisted of 24 municipalities. The level of education and income in Nord-Trøndelag was somewhat lower than the national Norwegian average, but the area was still considered representative of the general Norwegian population (Krokstad et al., 2004). All adults in the county were invited to participate, and the response rate was 54%. The participants completed two questionnaires, the first before attending health examination stations, the second afterwards. About 80% of participants returned the last questionnaire, resulting in a greater proportion of missing on certain variables. The sample in this study was 49,237 with a mean age at 53 years and 55% female respondents.

2.2. Geographical categorisation: Rural coast, urban coast, rural inland and rural fjord

We established geographical affiliation based on respondent's registered municipality. The 24 municipalities were classified into four geographical categories; rural coast, urban coast, rural inland and rural fjord. The classification of areas, and hereunder especially the rural coastal areas, was mainly based on municipality statistics from 1960 (supplementary material, Tables 1 and 3), collected from the Norwegian Centre for Research Data's (NSD) municipality database. These statistics show employment in fishing for each municipality before several substantial collapses in fish stocks and subsequent downturn in small-scale fishing in the later decades of last century (Christensen, 2014). Numbers from 2006 are obtained from the Norwegian Directorate of Fisheries, if not else specified. NSD and the Directorate of Fisheries are not responsible for analyses or interpretations in this study.

The primary interest of this study is rural coastal areas with a history of small-scale fishing, and five municipalities were classified as such areas. These municipalities share three coastal characteristics: Firstly, and most importantly, all five municipalities had a substantial proportion of inhabitants with their main occupation in fishing in 1960, ranging from 10 to 27 percent. This does not include employment in fisheries, such as fish conservation. The numbers are considerably higher if fishing as a side occupation is included (supplementary material, Table 2) (SSB, 1962a). In total, 17 percent of the workforce in these municipalities had their main occupation in fishing. Following the decline in small-scale fishing, this was reduced to 7 percent in 2006 (SSBa). Similarly, the number of vessels was reduced from 1575 to 198 (SSB, 1962b). While all coastal municipalities have shown a decrease in both employment in fishing and vessels, the size of landings has increased in one municipality (supplementary material, Table 2) (SSB, 1962c). The rural coastal population had a decline in inhabitants of 18.4 percent from 1960 to 2006.

It should be noted that many Norwegian coastal communities with long-standing small-scale fishing also have been, and still are, relying on larger scale fleets and fisheries (Vik et al., 2011). The Nord-Trøndelag county has however been an area with small vessels and few fisheries employees (supplementary material, Table 2) (Hovland, 2014; SSB, 1962b; SSB, 1962c; SSBb). The recent emergence of aquaculture has provided new coastal-related employment opportunities, and amounted to 315 out of the 529 employees in fishing in the county at the time of HUNT3. As for oil industries, Nord-Trøndelag County has close to no local employment in oil exploitation.

Secondly, these five municipalities all border to the big ocean instead of the county fjord, located by historical coastal shipping routes, and subsequent posing as long-standing coastal trading posts (Herje, 1999). Thirdly, the five municipalities have a low land-to-coast ratio, with an

Table 1
Characteristics of the study population and prevalence of employment, behavioural and psychosocial factors in geographical areas. The HUNT Study 2006–08 (HUNT3), adults 20+ years.

	Geographical affiliation				Total
	Rural coast	Urban coast	Rural inland	Rural fjord	
Population ≥20 years	8465	61,582	11,113	12,512	93,672
N	6449 (76)	31,282 (51)	6421 (58)	6650 (53)	48,583 (52)
Mean age	54	53	54	54	53
Men (%)	2908 (45)	14,243 (46)	2991 (47)	3069 (46)	22,211 (46)
Self-rated poor health (%)	34	24	26	29	26
Employment factors					
Class					
I	506 (12)	5156 (16)	759 (12)	760 (11)	7181 (15)
II	619 (15)	6183 (20)	1010 (16)	1110 (17)	8922 (18)
III	1293 (31)	9199 (29)	1792 (28)	1819 (27)	14,103 (29)
IV	583 (14)	2067 (7)	859 (13)	850 (13)	4359 (9)
V+VI	366 (9)	3267 (10)	621 (10)	709 (11)	4963 (10)
VII	630 (15)	3806 (12)	948 (15)	980 (15)	6364 (13)
Missing	233 (6)	1604 (5)	432 (7)	422 (6)	2691 (6)
Job sector					
Primary + secondary	1283 (30)	7636 (24)	1872 (29)	1970 (30)	12,761 (27)
Tertiary	2623 (62)	21,214 (68)	4020 (63)	3653 (55)	31,510 (65)
Missing	324 (8)	2432 (8)	529 (8)	1027 (15)	4312 (9)
Employment status					
Employed	2545 (60)	20,100 (64)	4025 (63)	4067 (61)	30,737 (63)
Retired	907 (21)	5878 (19)	1453 (23)	1468 (22)	9706 (20)
Student	136 (3)	1317 (4)	185 (3)	190 (3)	1828 (4)
Unemployed	593 (14)	3711 (12)	670 (10)	878 (13)	5852 (12)
Missing	49 (1)	276 (1)	88 (1)	47 (1)	460 (1)
Behavioural factors					
Smoking					
Never smoked	1611 (38)	12,953 (41)	2781 (43)	2936 (44)	20,281 (42)
Former smoker	1303 (31)	10,285 (33)	1934 (30)	2043 (31)	15,565 (32)
Daily smoker	909 (21)	5173 (17)	1074 (17)	1105 (17)	8261 (17)
Occasional smoker	279 (7)	2297 (7)	479 (8)	416 (6)	3471 (7)
Missing	128 (3)	574 (2)	153 (2)	150 (2)	1005 (2)
Alcohol					
Abstinent	1030 (24)	5936 (19)	1426 (22)	1608 (24)	10,000 (21)
Moderate	2670 (63)	21,860 (70)	4326 (67)	4291 (65)	33,147 (68)
Excessive	169 (4)	1666 (5)	226 (4)	243 (4)	2304(5)
Missing	361 (9)	1820 (6)	443 (7)	508 (8)	3132 (6)
Physical activity					
Inactive	455 (11)	2871 (9)	687 (11)	629 (9)	4642 (10)
Moderately active	1850 (44)	15,003 (48)	3113 (49)	3223 (48)	23,189 (48)
Active	820 (19)	6603 (21)	1373 (21)	1366 (21)	10,162 (21)
Missing	1105 (26)	6805 (22)	1248 (19)	1432 (22)	10,590 (22)
Psychosocial factors					
Help from friends					
No	210 (5)	1191 (4)	273 (4)	274 (4)	1948 (4)

(*continued on next page*)

Table 1 (*continued*)

	Geographical affiliation				Total
	Rural coast	Urban coast	Rural inland	Rural fjord	
Yes	3043 (72)	23,924 (76)	5051 (79)	5102 (77)	37,120 (76)
Missing	977 (23)	6167 (20)	1097 (17)	1274 (19)	9515 (20)
Sense of community					
Uncertain/ disagree	716 (17)	6756 (22)	1072 (17)	1044 (16)	9588 (20)
Agree	2523 (60)	18,346 (59)	4244 (66)	4319 (65)	29,432 (61)
Missing	991 (23)	6180 (20)	1105 (17)	1287 (19)	9563 (20)
Anxiety symptoms					
< 8	2643 (62)	20,994 (67)	4370 (68)	4370 (66)	32,377 (67)
≥ 8	479 (11)	3264 (10)	794 (12)	785 (12)	5322 (11)
Missing	1108 (26)	7024 (22)	1257 (20)	1495 (22)	10,884 (22)
Depression symptoms					
< 8	2846 (67)	22,261 (71)	4610 (72)	4654 (70)	34,371 (71)
≥ 8	316 (7)	2133 (7)	589 (9)	562 (8)	3600 (7)
Missing	1068 (25)	6888 (22)	1222 (19)	1434 (22)	10,612 (22)

area average of 0.46 km^2 land per km of coastline. This implies greater physical proximity to the coast for the inhabitants compared to other areas.

Five municipalities were classified as urban areas. These municipalities had town areas in both 1960 and 2006, and these municipalities have experienced significant growth in inhabitants from 1960 to 2006 (31 percent increase in total). All urban municipalities border to the coast, four of them in fjord areas, with a total land-to-coast ratio of 24.7 km^2 land per km of coastline.

The remaining rural municipalities were divided into two categories; rural fjord and rural inland. These municipalities are inland and fjord areas with no pronounced history of coastal involvement through fishing (1.6 and < 1 percentage of the total workforce in 1960, respectively). Still, the fjord and inland areas differ significantly in land-to-coast ratio (4.88 km^2 and no coastline, respectively). Considering former studies revealing possible health effects of coastal proximity (Wheeler et al., 2012; White et al., 2013; Garrett et al., 2019; Pasanen et al., 2019), our study validity most likely benefits from differentiating between these areas.

2.3. Measurement of health

The outcome in this study is self-rated general health. Self-rated health is a widely used and recommended health measure in a number of studies; it has been validated numerous times and has been shown to have strong predictive ability on mortality, morbidity and work-related disability (DeSalvo et al., 2005; Fosse and Haas, 2009; Schou et al., 2006).

The original variable for self-rated health was measured by the question “How is your health at the moment?” with four response alternatives: “Poor”, “Not so good”, “Good” and “Very good”. Due to a highly skewed distribution of this variable, with only 1.46 percent responding “Poor”, the responses “Poor” and “Not so good” were merged into “Poor self-rated health”, while the responses “Good” and “Very good” were merged into “Good self-rated health”, functioning as the reference group.

2.4. Employment, behavioural and psychosocial factors

We included employment factors indicating different aspects of respondent’s current or former connections to the labour market. As restructuring of societies may afflict differently according to occupational class (Pickett and Pearl, 2001), class affiliation was included as an indicator of socioeconomic position. Class was derived from respondents’ occupations and classified into a six-level scale based on the Erikson Goldthorpe class scheme (Erikson and Goldthorpe, 1992) (I: Administrative leaders and politicians, and academic occupations; II: Occupations with shorter college or university degrees; III: Office and customer service workers, and sale-, service- and caring professions; IV: Occupations within farming and fishing; V+VI: Skilled craftsmen; VII: Process- and machine operators, and occupations with no required training or education). As the original employment variable provided no distinction of self-employed workers in primary production, all employment in farming, forestry and fishing was categorised as class “IV”. This was set as the reference group to provide comparisons to this group. Considering the great decline of jobs in fishing and the potential increased risk of unemployment in coastal areas, we included an indicator of employment status (employed, retired, in education and unemployed). Employed is set as the reference group, as it represents a perceived standard state. Job sector (primary + secondary and tertiary sector) was included as an indicator of physical strain in the work place, as the physically challenges of fishing (Thorvaldsen et al., 2016) may suggest harder jobs outside the tertiary sector in coastal areas. All employment variables included respondents who are no longer employed, which to some extent averts the healthy worker effect (Shah, 2009).

Behavioural factors included smoking, alcohol consumption and physical activity. These are all associated with several measurements of health (Jepson et al., 2010), and reported to be more prevalent in fishing occupations (Koren, 2017; Matheson et al., 2001; Thorvaldsen et al., 2016). Smoking included categories of never smoked, former smoker, daily smoker and occasional smoker. Daily smoking, even at very low quantities, is associated with a substantial increased risk of developing coronary heart disease and stroke (Hackshaw et al., 2018). Alcohol consumption is an aggregate of three variables where respondents reported the units consumed of beer, wine and spirits over the last two weeks. Based on the total sum, categories of abstinent, moderate (1–14 drinks in two weeks) and excessive (>14 drinks in two weeks) were derived. Physical activity was derived from two questions asking the respondent to report number of hours per week spent on light and hard physical activity. Hard physical activity was given twice as much weight as light physical activity, and the combined aggregate was classified into three categories (inactive 0–1 h per week, moderately active 2–5 h a week, active 6–9 h per week). To aid in an intuitive interpretation, reference groups are set to the unexposed category, regardless of whether the factor is anticipated to have negative or positive affect on health.

To capture social integration and support of the society, we included questions regarding whether the respondents felt they had friends who could help them in times of need (yes, no), and whether the respondents had a strong sense of community with the people where they live (originally five categories dichotomised: disagree/uncertain and yes). In addition, we included symptoms of anxiety and depression. These were measured by The Hospital Anxiety and Depression (HAD) rating scale, an established self-rating instrument consisting of 14 four-point Likert-scaled items; 7 for anxiety (HADS-A) and 7 for depression (HADS-D) (Mykletun et al., 2001; Stern, 2014). The scores were dichotomised at the recommended cut-off at ≥8 (Stern, 2014). One might anticipate that people to some degree take their mental health into account when reporting their self-assessed health (Au and Johnston, 2014), challenging the role as predictor of self-rated health. Still, as applicable to the widely used measurements of physical activity, the causal relationship is complicated. As symptoms of anxiety and depression have been found to play a mediating role between community characteristics and health, the inclusion can aid us in illuminating the underlying mechanisms of geographical affiliation and self-rated health; the coastal population might be more exposed to psychosocial distress, which is recognised as an important factor in major physical health outcomes (Matthews and Gallo, 2011).

2.5. Statistical analysis

Although we have depicted the change of coastal involvement over time, it should be noted that this is a cross-sectional study aiming to assess the health in coastal areas at a specific time point succeeding several important changes in coastal industries. Logistic regression models were specified to examine associations between self-rated health and geographic affiliation. Specifically, we regressed poor self-rated health on geographic affiliation (ref = urban coastal population), adjusting for age and gender. Missing responses were handled through full information maximum likelihood, an adequate alternative to multiple imputation (Peyre et al., 2010). Odds ratios (OR) were calculated for categories of geography, adjusted for age and gender in the reference model. This model was further adjusted for employment, behavioural and psychosocial factors separately, adjusted for combinations of two groups, and finally adjusted for all factors simultaneously. Analyses stratified by gender and age group are available in the supplementary material (Tables 4–7). The percentage change in OR between models were calculated for each geographical category: [100 x (OR reference model – OR individual factors)/(OR reference model – 1)]. We will report changes in OR's in percentages, as these express how much of the excess likelihood of poor self-rated health is reduced.

The method of stepwise adjustment of factors and assessment of change in measure of association has been used to study several measurements of health (van Oort et al., 2005; Skalická et al., 2009; van Hedel et al., 2018; Stronks et al., 1996). It allows us to assess both independent and overlapping contributions of factors. Independent effects of each factor were calculated by comparing models with two groups of factors and the corresponding two models with each one group of factors; we subtracted the percentage reduction of OR of the model without a specific factor from a model including this factor. Example: The independent contribution of psychosocial factors is calculated as the percentage reduction of the odds ratios of model 5 minus the percentage reduction of the odds ratios of model 2. Overlapping effects were derived similarly, by subtracting the independent contribution of a specific factor from the total contribution that factor. Example: For psychosocial factors, the total contribution equals model 4. The calculation of overlapping effects has in several former studies been used to assess potential indirect effects between factors (Skalická et al., 2009; van Oort et al., 2005; Stronks et al., 1996). In this study, we define overlapping effects as indirect contributions of one factor through another. If the overlap is ignored, this could lead to an overestimation of individual effects of factors. However, it should be noted that this is a cross-sectional study, and although our calculations may indicate potential indirect contributions, causation and mediation is not proved through this methodology. Analyses were performed in Mplus (version 8) (Muthén and Muthén, 1998–2017). All effects are reported as odds ratios with 95 percent confidence intervals (95% CI). Relative measures of fit are reported by values of Akaike information criterion (AIC) and Bayesian information criterion (BIC).

3. Results

Table 1 shows general characteristics of the study population. Rural coast had the highest participation in the HUNT Study. There was no apparent skewness regarding age and gender between the geographical categories. The proportion of self-rated poor health was highest in the rural coastal population (34%) and lowest in the urban coastal population (24%). Factors such as daily smoking, unemployment, and lack of support from friends were more prevalent in the rural coastal population compared to the other geographical categories, but the differences were modest. Compared to the two rural populations of inland and fjord, the rural coastal population had a lower prevalence of sense of community. All factors except job sector were statistically associated with poor self-rated health when adjusting for geographical affiliation (Table 2).

Table 3 exhibits calculated odds for each geographical category, with the urban coastal population set as reference. Compared to the urban coastal population the odds for poor self-rated health were higher in all rural categories. The odds for the rural inland population were only slightly increased and not statistically significant. The non-overlapping confidence intervals of the rural coastal and rural fjord odds ratios indicate statistically significant differences between these groups (Fig. 1; Table 3, Model 1).

Each model with further adjustments is represented by the new calculated odds ratio for each geographical category, as well as changes in odds ratio from model 1 in percent. For the rural coastal population, Table 3 shows that adjustment for behavioural factors lowered the odds ratio most (17%, Model 3), followed by employment factors (13%, Model 2), whereas adjustment for psychosocial factors had no impact on the odds ratio (Model 4). The increased odds of poor self-rated health in the rural coastal population remained statistically significant after each adjustment for individual factors. Stratified analyses (Supplementary tables 4-7) showed that behavioural factors resulted in the biggest independent change in odds in the rural coastal population for both genders and the older population. For the younger population, employment factors resulted in a slightly greater change inn odds compared to

Table 2
Age and gender adjusted effects on poor self-rated health of employment, behavioural, psychosocial factors, controlling for geographical affiliation.

	OR	95% CI
Employment factors		
Class		
I	0.69	(0.61–0.77)
II	0.73	(0.65–0.82)
III	1.03	(0.92–1.15)
IV	-	
V+VI	1.01	(0.91–1.12)
VII	0.92	(0.83–1.02)
Job sector		
Primary + secondary	–	
Tertiary	0.98	(0.91–1.06)
Employment status		
Employed	–	
Retired	1.34	(1.23–1.46)
Education	1.08	(0.92–1.25)
Unemployed	3.00	(2.80–3.20)
Behavioural factors		
Smoking		
Never smoked	–	
Former smoker	1.37	(1.30–1.45)
Daily smoker	1.58	(1.48–1.69)
Occasional smoker	1.15	(1.04–1.27)
Alcohol		
Abstinent	–	
Moderate	0.72	(0.68–0.76)
Excessive	0.64	(0.56–0.72)
Physical activity		
Inactive	–	
Moderately active	0.60	(0.56–0.65)
Active	0.42	(0.38–0.46)
Psychosocial factors		
Help from friends		
Yes	–	
No	1.49	(1.34–1.65)
Feeling of community		
Agree	–	
Uncertain/disagree	1.22	(1.15–1.29)
Anxiety symptoms		
< 8	–	
≥ 8	2.40	(2.24–2.58)
Depression symptoms		
< 8	–	
≥ 8	2.33	(2.15–2.53)

Table 3
ORs and proportional change for poor self-rated health by geographical affiliation. The HUNT Study 2006–08 (HUNT3), adults 20+ years.

	Model	Rural coast			Rural inland			Rural fjord			Urban coast	AIC/BIC
		OR	95% CI	Change	OR	95% CI	Change	OR	95% CI	Change	OR	
1	Age and gender	**1.53**	(1.43–1.65)		1.05	(0.99–1.12)		**1.23**	(1.15–1.30)		1.00 (Ref.)	615,837 616,066
2	Employment	**1.46**	(1.36–1.57)	13	1.03	(0.97–1.10)	40	**1.18**	(1.11–1.26)	22	1.00 (Ref.)	771,500 772,680
3	Behavioural	**1.44**	(1.34–1.55)	17	1.03	(0.97–1.10)	40	**1.21**	(1.14–1.29)	9	1.00 (Ref.)	817,773 818,680
4	Psychosocial	**1.53**	(1.42–1.64)	0	1.01	(0.94–1.08)	80	**1.21**	(1.13–1.29)	9	1.00 (Ref.)	683,571 684,134
5	Employment + psychosocial	**1.46**	(1.35–1.58)	13	1.00	(0.93–1.07)	100	**1.17**	(1.10–1.25)	26	1.00 (Ref.)	838,636 840,467
6	Employment + behavioural	**1.40**	(1.30–1.51)	25	1.03	(0.96–1.10)	40	**1.18**	(1.11–1.26)	22	1.00 (Ref.)	969,593 972,006
7	Behavioural + psychosocial	**1.45**	(1.34–1.56)	15	0.99	(0.93–1.06)	100	**1.20**	(1.12–1.28)	13	1.00 (Ref.)	884,764 886,252
8	Employment + behavioural + psychosocial	**1.41**	(1.31–1.52)	23	0.99	(0.93–1.06)	100	**1.17**	(1.10–1.25)	18	1.00 (Ref.)	1036088 1039399

Values in bold does not include the OR 1.00.
Overlapping CI intervals indicate no statistically significant difference between groups.

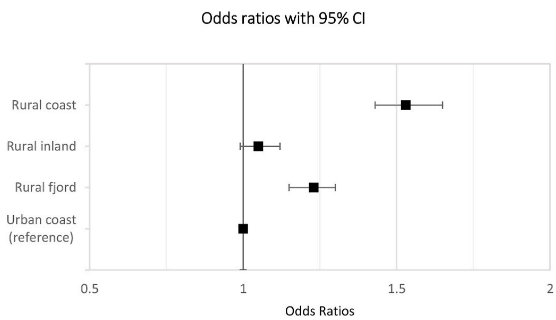

Fig. 1. Age- and gender-adjusted ORs for poor self-rated health by geographical affiliation. Urban coastal population as reference category. The HUNT Study 2006–08 (HUNT3), adults 20+ years.

behavioural factors.

For the rural inland population, psychosocial factors contributed to the biggest change in odds ratio (80%, Model 4), followed by employment and behavioural factors (40%, Model 2 and 3). The odds for the rural inland population remained not statistically significant after each adjustment. For the rural fjord population, the adjustment for employment factors contributed with the biggest change in odds (22%, Model 2), followed by behavioural and psychosocial factors (9%, Model 3 and 4). The odds for the rural fjord population remained statistically significant after each adjustment.

Simultaneous adjustment for individual factors revealed differing independent and indirect contributions between the geographical populations. Because of the small and exclusively non-significant differences between the rural inland population and the reference group, the independent and indirect contributions of individual factors for the inland population are reported as illustrations in the supplementary material (Fig. 1).

For the rural coastal population, simultaneous adjustment for employment and psychosocial factors (Table 3, Model 5) had the same impact on the odds as adjustment for employment factors only, whereas the rural fjord population showed an increase of odds by 4 percentage points. Our findings indicate that none of the contribution of employment factors was through psychosocial factors for the rural coastal population, but partly for the rural fjord population (5 percentage points) (Fig. 2). Simultaneous adjustment for employment factors and behavioural factors lowered the odds more than adjustment for employment factors only for the rural coastal population (12 percentage points), but not for the fjord population. As shown in Fig. 2, this points to that 5 percentage points of the contribution of employment factors was through behavioural factors in the rural coastal population. Simultaneous adjustment for behavioural factors and psychosocial factors lowered the odds less than individual adjustment for behavioural factors for the rural coastal population (2 percentage points), whereas it lowered the odds more for the rural fjord population (4 percentage points). Our findings indicate a small contribution of behavioural factors through psychosocial factors for the rural coastal population (2 percentage points), and a higher indirect contribution for the rural fjord population (5 percentage points) (Fig. 2). Finally, adjustment for all individual factors simultaneously lowered the odds for the rural coastal and fjord population by 23% and 18%, respectively. AIC and BIC values indicated that model 1 provided the best model for our data. Of the individual factors, psychosocial factors provided the best fit.

4. Discussion

Our aim was to examine the contribution of employment, behavioural and psychosocial factors in the explanation of geographical inequalities in health, with special emphasis on understanding coastal public health in rural areas with a history of small-scale fishing. When adjusting for age and gender, the rural coastal population showed the highest odds of poor self-rated health compared to the urban coastal population, followed by the fjord population. The rural inland population showed no significant difference in odds of poor self-rated health compared to the urban coastal population. Our findings indicate health differences between populations in close proximity to the coast, and provide additional insights and nuances to former studies indicating a positive association between coastal proximity and health (Wheeler et al., 2012; White et al., 2013). Adjustments for employment, behavioural and psychosocial factors had varying effects on the odds of poor self-rated health in different geographical populations. Nonetheless, they contributed to explain some of the increased risk of poor self-rated health between all geographical affiliations and the urban coastal population.

Employment factors contributed to a smaller change in likelihood of poor self-rated health in the rural coastal population compared to the rural fjord population. This finding is somewhat unexpected, considering their differing historical employment related to their coastal surroundings; the rural coastal areas of Nord-Trøndelag, as opposed to the

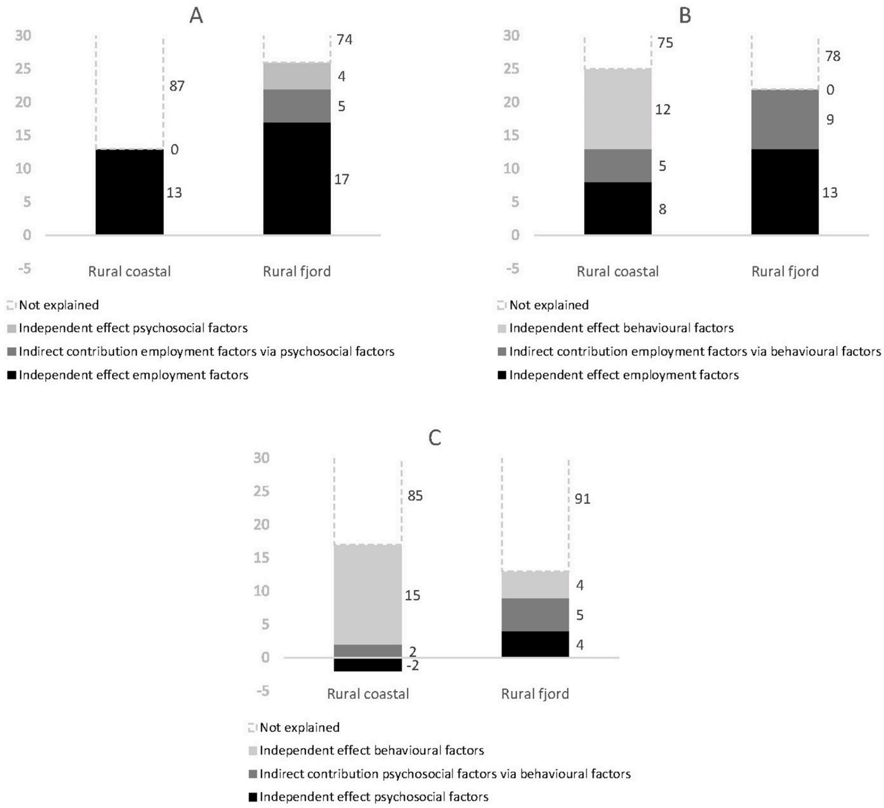

Fig. 2. (A) Independent and indirect contributions of (A) employment factors and psychosocial factors, (B) employment factors and behavioural factors, and (C) psychosocial factors and behavioural factors to the explanation of the odds ratio of geographical categories. The urban coastal population is reference group.

rural fjord areas, are communities with a long tradition of coastal-based industries and occupations through fishing. Therefore, the smaller contribution of class affiliation, employment and work sector in the rural coastal population challenges the assumption of greater health hazards related to the physical hardship or significant decline in fishing. Considering that new coastal industries, such as aquaculture, have provided a heterogeneity to the occupations in fishing-related activities (Iversen et al., 2020), the physical hardship of the traditional fisher may not be transferrable to new occupations in the fishing industry, therefore perhaps posing less health risks. There has also been a formidable technological development in fishing methods (Vik et al., 2011), potentially lessening the workload for those currently employed in fishing.

Simultaneous adjustments indicated no indirect contribution of employment factors through psychosocial factors for the rural coastal population, whereas they did indicate such indirect contribution for the rural fjord population. This finding suggests smaller psychosocial health hazard connected to the employment in rural coastal areas. The independent effect of employment factors was still larger for the rural fjord population, further challenging the assumption of more health hazards inflicted *directly* by the physical coastal-based employment (Hundstad, 2014). This is further supported by the simultaneous adjustment for employment and behavioural factors, which also indicated a smaller remaining effect of employment factors for the rural coastal population compared to the rural fjord population. This adjustment also signals a smaller indirect contribution of employment factors through behavioural factors for the rural coastal population. This suggests that the coastal-based employment situation may have some, but no outstanding, infliction on health through subsequent lifestyle choices (Thorvaldsen et al., 2016; Koren, 2017).

Behavioural factors contributed with the biggest change in odds of poor self-rated health for the rural coastal population. This finding is not unexpected, as the contribution of lifestyle factors on health has been studied immensely and indisputably acknowledged (Jepson et al., 2010). Nonetheless, the smaller contribution of behavioural factors in the rural fjord population suggests that poor rural coastal health to a greater extent is related to lifestyle compared to its fjord counterpart. Of the behavioural factors, the prevalence of daily smoking is higher in the rural coastal population compared to the other geographical categories (Table 1). On average, the prevalence of smoking is declining in Norway (FHI, 2018). Lifestyle trends are generally found to change more slowly in rural areas (Elstad and Koløen, 2009), but the higher prevalence of smoking in the rural coastal areas compared to fjord and inland points to a potential distinct relation between smoking and traits of the coastal communities. As daily smoking has been found to be more prevalent in active fishers compared to the general population (Thorvaldsen et al., 2016), the stronger association between lifestyle factors and self-rated health in rural coastal areas might be related to a maintaining of former lifestyle habits related to such activities.

However, as mentioned, the simultaneous adjustments for individual factors indicated a smaller indirect contribution of employment factors through behavioural factors for the rural coastal population compared to the fjord population, suggesting no outstanding behavioural effects on rural coastal health related to employment in the coastal industry. Our findings indicated a considerable independent effect of behavioural factors in the rural coastal population, a trait not shared by the rural fjord population. This is further supported by the simultaneous adjustment of psychosocial and behavioural factors, which also indicated a considerably greater independent effect of behavioural factors in the rural coastal population.

The individual adjustment of psychosocial factors had no effect on the odds of poor self-rated health for the rural coastal population, a finding that was somewhat unexpected considering the potential negative impact of the lessened social reliance in many Norwegian coastal communities (Johansen, 2014; Hundstad, 2014). Nevertheless, our data show small differences in prevalence of anxiety and depression symptoms between all populations, the two psychosocial factors strongest associated with poor self-rated health (Table 2). Our findings challenge the assumption of potential health-impairing psychosocial burdens of dissolving rural coastal communities due to recent decades' decline in small-scale fishing and subsequent outmigration and potential changes in social dependence. Considering the emergence of new coastal industries, such as the growing aquaculture (Giskeødegård, 2014), one might argue that the psychosocial stress of a societal transition is hampered by new alternatives of employment and livelihoods. Contrarily, the rural fjord population had a reduction in likelihood of poor self-rated health, and the simultaneous adjustments indicated small, but stronger, independent effects of psychosocial factors.

In all, our findings indicate a poorer health situation in both the rural coastal and rural fjord population compared to the urban coastal population. This urban-rural health divergence between the coastal populations is partly in line with former research, which found a weaker association between coastal proximity and general health in rural areas compared to more urbanised areas (Wheeler et al., 2012). Moreover, our findings indicate differing health situations between the rural coastal-involved areas and rural fjord areas, despite sharing the trait of rurality and physical proximity to the coastline. The individual and simultaneous adjustments for employment, behavioural and psychosocial factors imply differing compositional mechanisms underlying the association between self-rated health and rural coastal and rural fjord areas. These findings can be seen as augmentations to existing research on coastal health (Pasanen et al., 2019; Garrett et al., 2019; White et al., 2013), as our proposed categorisation of coastal populations provides a tool to assess health-related differences between different coastal-based populations. In addition, our findings suggest that the rural inland population exhibits a different health situation compared to its rural coastal and fjord counterparts, contesting assumptions of poor self-rated health being solely attributed to rurality.

The narrowing gap in self-rated health between the geographical categories after adjusting for employment, behavioural and psychosocial factors indicates that the underlying mechanisms of poor coastal health to some extent are compositional in nature. Still, there is no straightforward classification of compositional and contextual effects, as they can be intertwined and are often applicable to both individual and structural levels (Macintyre et al., 2002). The increased prevalence of a behavioural factor, such as smoking in rural coastal areas, can be considered as an individual trait of the respondents. Nonetheless, they can also be intertwined with larger scale unemployment, the history of coastal-based occupations and potentially associated health risk behaviours (Shaw et al., 2002; Diez-Roux, 1998). Considering that most of the association between geographical affiliation and self-rated health remains unexplained, a potential overlapping between compositional and contextual effects should be considered and studied further. Nevertheless, our results are relevant to public health and preventive medicine. Since lifestyle had the biggest independent effect on likelihood of poor self-rated health in rural coastal areas, it is theoretically possible to improve the health of the coastal population through measures influencing health behaviour.

4.1. Limitations

There are some limitations with our study that should be noted. Firstly, the limitations of the cross-sectional design must be emphasised. Our study is descriptive, thus providing limited information about potential causal and mediating relationships between geographical affiliation and self-rated health. Our results show changes in odds for poor self-rated health when adjusting for employment, behavioural and psychosocial factors, however we cannot conclude that these factors are mediators in a causal relationship between coastal living and poor self-rated general health. As we have limited information about whether rural coastal communities attract people of poorer health or if coastal communities provide a context or culture in which risk factors are more prominent, our study is ultimately a description of what lies within the association between coastal settlements and health. Relatedly, our methodological design does not provide clear indications of whether the individual factors constitute potential confounders, nor whether there are reverse causal effects between them.

Secondly, we have limited the empirical foundation of this study to the wide and general measurement of self-rated health. It is not in the scope of this article to assess a wide range of illnesses, and it should be noted that the results reported for self-rated health might differ from other measurements of health. Further research on the underlying mechanisms in coastal health would benefit from including other health outcomes, providing further knowledge on the topic.

Thirdly, our study could have benefitted from inclusion of other compositional factors in our analyses, especially regarding employment factors. Educational level was considered as a substitute for class affiliation. This could have provided a greater foundation of comparison, as the effects of education on health has been studied extensively (Elstad and Koløen, 2009; Gerdtham and Johannesson, 2001). Still, considering the pronounced egalitarian nature of Norwegian society, educational level is not necessarily a valid measure or reflection of social position or placement in the occupational hierarchy (Elstad and Koløen, 2009). This might be especially relevant in smaller places, as social class based on occupation might be shaped by the local labour market (Macintyre et al., 2002). Employment factors could also have been extended to include traits of the respondents work situation, giving us the opportunity to study the association between individual experience of physical hardship at work and self-rated health. Still, this was excluded from the analyses due to the potential healthy worker effect (Shah, 2009), as the available measurements were from currently employed respondents only.

Finally, our study involves geographical definitions not solely based on coastal proximity, as seen in former studies and population statistics (White et al., 2013; ONS, 2014; Garrett et al., 2019). This limits the opportunity for direct comparison with existing literature. Still, we argue that our geographical classification is a substantial methodological strength of our study, enabling the assessment of coastal health while also accounting for both coastal involvement and the urban-rural dimension. Relatedly, the coastal-revolved demographics of our total study region do not provide the opportunity of including an urban inland category in our analyses. This limits a comparable illumination of the urban-rural aspect of health in coastal and inland populations. By extension, the urban category of our study contains municipalities that might have been classified as towns or suburban areas in countries with a different demography.

5. Conclusion

By introducing a more fine-grained classification of coastal areas, we found a statistically significant higher likelihood of poor self-rated health in both rural coastal and rural fjord areas compared to urban coastal areas. Rural coastal areas, with a long-standing history of coastal involvement through small-scale fishing, also had a considerably higher likelihood of reporting poor health compared to rural fjord areas, which are areas with no substantial fishing activity. Stepwise and simultaneous adjustments for employment, behavioural and psychosocial factors indicated differences in underlying compositional mechanisms between the rural coastal and rural fjord population, despite sharing the trait of coastal proximity. Considering the international trend of decline in small-scale fishing potentially affecting many rural coastal communities, our findings hopefully encourage further reflections regarding the definition of coastal areas when assessing geographical inequalities in health. The contribution of behavioural factors was more prominent in the rural coastal areas with a long-standing history of coastal involvement, and further research could therefore also benefit from examining lifestyle habits in coastal populations.

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Author statement

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Declaration of competing interest

None.

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Appendix ASupplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2020.113286.

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Supplementary material: Understanding coastal public health. Employment, behavioural and psychosocial factors associated with geographical inequalities. The HUNT Study, Norway

Table 1: Municipality characteristics of (former) Nord-Trøndelag county 1960 and 2006

		1960				2006			
Municipality	Km^2 land per km coastline	Inhabitants	Employed (total)	Employed in fishing (main occupation)	Percentage of total employment in fishing	Inhabitants	Employed (total)	Employed in fishing and aquaculture (main occupation)	Percentage of total employment in fishing and aquaculture
Rural coast									
Fosnes	2.53	974	327	40	12.2	714	338	21	6.2
Flatanger	0.56	1703	630	148	23.5	1174	563	58	10.3
Vikna	0.13	3880	1458	398	27.3	4011	2071	188	9.1
Nærøy	0.85	6604	2380	232	9.7	5154	2397	100	4.2
Leka	0.25	1105	404	75	18.6	595	288	30	10.4
Urban (coast)									
Steinkjer	16.55	18922	6920	10	<1	20477	10028	8	<1
Namsos	1.51	10775	4162	57	1.4	12574	6236	48	<1
Stjørdal	19.43	12917	4711	2	<1	19892	10298	14	<1
Levanger	3.79	12922	4753	25	<1	18080	8929	17	<1
Verdal	82.19	9087	3307	6	<1	13900	6815	4	<1
Rural inland									
Meråker	-	3352	1177	0	0	2531	1157	4	<1
Snåsa	-	3244	1126	0	0	2251	1109	0	0
Lierne	-	2018	746	0	0	1503	778	0	0
Røyrvik	-	461	188	0	0	544	282	0	0
Namsskogan	-	1693	595	0	0	919	455	1	<1
Grong	-	3107	1055	1	<1	2416	1189	1	<1
Høylandet	35.14	1546	519	3	<1	1279	645	8	1.2
Overhalla	344.22	3511	1193	0	0	3493	1807	3	<1
Rural fjord									
Frosta	1.14	2940	961	38	4	2467	1171	5	<1
Leksvik	8.16	2913	1087	8	<1	3496	1726	1	<1
Mosvik	2.98	1241	435	9	2	893	439	2	<1
Verran	7.86	4589	1577	11	<1	2644	1069	9	<1
Namdalseid	7.82	2156	732	26	3.6	1749	821	5	<1
Inderøy	1.32	4982	1706	14	4	5938	2956	2	0.6

Table 2: Numbers for fishers, landings, vessels, aquaculture and fish conservation of (former) Nord-Trøndelag county and coastal municipalities 1960 and 2006

	Inhabitants	Employed (total)	Employed in fishing and aquaculture (main occupation)	Registered fishers (main and side occupation)	Percentage of total employment in fishing (main and side occupation)	Landings (tons)	Vessels (total)	Vessels < 11 meters[1]	Vessels 11-14.99 meters	Vessels above 15 meters	Active licenses in aquaculture	Employed in aquaculture	Employed in fish conservation
County total													
1960	116642	42149	1103	1726	4.1	33 320[2]	1575 (100)	1499 (95.2)	52 (3.3)	24 (1.5)	*[3]	*[3]	126
2006	128694	63567	529	314	<1	36 974	198 (100)	161 (81.3)	28 (14.1)	9 (4.5)	127	315	279[4]
Fosnes													
1960	974	327	40	115	35.2	466	53[5]						
2006	714	338	21	1	<1	*[6]	1						
Flatanger													
1960	1703	630	148	219	34.8	1866	99						
2006	1174	536	58	17	3.2	679	9						
Vikna													
1960	3880	1458	398	503	34.5	8008	234						
2006	4011	2071	188	151	7.3	33 062	112						
Nærøy													
1960	6604	2380	232	435	18.3	7818	197						
2006	5154	2397	100	71	3	2 723	47						
Leka													
1960	1105	404	75	137	33.9	1593	58						
2006	595	288	30	15	5.2	181	10						

[1] All vessel lengths of 1960 are converted from feet to new standards of meters.

[2] Original landings were not reported in round weight for each county or municipality in 1960. Round weight was calculated based on the difference between dressed and round weight of the national landings in 1960, which equals an increase of 15.82 percent.

[3] No aquaculture activity of the county in 1960.

[4] Numbers from 2007

[5] Vessel counts for each municipality is from 1980 because of first available statistic.

[6] No numbers reported.

Grey areas indicate no available numbers.

Table 3: Coastline, population and employment characteristics of the geographical categories

	Km^2 land per km coastline (total)	Percentage of total employment in fishing 1960	Percentage of total employment in fishing and sea transport 2006	Percentage change in population (total)	Employed to unemployed ratio 2006[1]
Rural coast	0.46	17.2	7	-18.4	34
Urban (coast)	6.39	<1	<1	+31.4	45
Rural inland	506.51	<1	<1	-21.1	67
Rural fjord	4.62	1.6	<1	-8.7	45

[1] Based on registered unemployment. Numbers not available for 1960.

Table 4: ORs and proportional change for poor self-reported health in men by geographical affiliation

		Rural coast			Rural inland			Rural fjord			Urban coast
	Model	**OR**	**95% CI**	**Change**	**OR**	**95% CI**	**Change**	**OR**	**95% CI**	**Change**	**OR**
1	Age	**1.55**	(1.39-1.73)		1.15	(1.04-1.26)		**1.36**	(1.24-1.49)		1.00
2	Employment	**1.49**	(1.34-1.67)	11	1.11	(1.00-1.22)	27	**1.29**	(1.18-1.42)	19	1.00
3	Behavioural	**1.46**	(1.30-1.63)	16	1.14	(1.04-1.26)	7	**1.34**	(1.22-1.47)	6	1.00
4	Psychosocial	**1.54**	(1.38-1.73)	2	1.12	(1.01-1.24)	20	**1.33**	(1.21-1.46)	8	1.00
5	Employment + psychosocial	**1.49**	(1.33-1.68)	11	1.08	(0.98-1.20)	47	**1.27**	(1.15-1.40)	25	1.00
6	Employment + behavioural	**1.43**	(1.27-1.60)	22	1.11	(1.01-1.23)	27	**1.29**	(1.17-1.42)	19	1.00
7	Behavioural + psychosocial	**1.46**	(1.30-1.64)	16	1.12	(1.01-1.24)	20	**1.31**	(1.19-1.45)	14	1.00
8	Employment + behavioural + psychosocial	**1.44**	(1.28-1.62)	20	1.09	(0.98-1.21)	40	**1.26**	(1.14-1.40)	28	1.00

Values in bold does not include the OR 1.00.
Overlapping CI intervals indicates no statistically significant difference between groups.

Table 5: ORs and proportional change for poor self-reported health in women by geographical affiliation

		Rural coast			Rural inland			Rural fjord			Urban coast
	Model	**OR**	**95% CI**	**Change**	**OR**	**95% CI**	**Change**	**OR**	**95% CI**	**Change**	**OR**
1	Age	**1.52**	(1.38-1.67)		0.98	(0.90-1.07)		**1.13**	(1.04-1.23)		1.00
2	Employment	**1.43**	(1.30-1.58)	17	0.98	(0.90-1.07)	0	**1.10**	(1.01-1.20)	23	1.00
3	Behavioural	**1.42**	(1.29-1.57)	19	0.95	(0.87-1.04)	(-)150	**1.13**	(1.03-1.22)	0	1.00
4	Psychosocial	**1.51**	(1.37-1.67)	2	0.93	(0.85-1.02)	(-)250	**1.13**	(1.03-1.23)	0	1.00
5	Employment + psychosocial	**1.43**	(1.30-1.59)	17	0.93	(0.85-1.02)	(-)250	**1.10**	(1.01-1.20)	23	1.00
6	Employment + behavioural	**1.38**	(1.25-1.53)	27	0.96	(0.88-1.05)	(-)100	**1.11**	(1.01-1.20)	15	1.00
7	Behavioural + psychosocial	**1.43**	(1.29-1.58)	17	0.90	(0.83-0.99)	(-)400	**1.12**	(1.02-1.22)	8	1.00
8	Employment + behavioural + psychosocial	**1.39**	(1.25-1.54)	25	0.92	(0.84-1.01)	(-)300	**1.10**	(1.01-1.21)	23	1.00

Values in bold does not include the OR 1.00.
Overlapping CI intervals indicates no statistically significant difference between groups.

Table 6: ORs and proportional change for poor self-reported health in age group 19-49 by geographical affiliation

		Rural coast			Rural inland			Rural fjord			Urban coast
	Model	**OR**	**95% CI**	**Change**	**OR**	**95% CI**	**Change**	**OR**	**95% CI**	**Change**	**OR**
1	Gender	**1.34**	(1.18-1.53)		0.97	(0.86-1.09)		**1.20**	(1.07-1.34)		1.00
2	Employment	**1.24**	(1.09-1.42)	29	0.94	(0.83-1.06)	(-)100	**1.13**	(1.00-1.27)	35	1.00
3	Behavioural	**1.26**	(1.11-1.44)	24	0.96	(0.85-1.09)	(-)33	**1.19**	(1.06-1.33)	5	1.00
4	Psychosocial	**1.31**	(1.14-1.50)	9	0.95	(0.84-1.08)	(-)67	**1.14**	(1.02-1.29)	30	1.00
5	Employment + psychosocial	**1.22**	(1.06-1.41)	35	0.92	(0.81-1.05)	(-)167	**1.09**	(0.97-1.23)	55	1.00
6	Employment + behavioural	**1.20**	(1.05-1.38)	41	0.95	(0.84-1.08)	(-)67	**1.14**	(1.01-1.28)	30	1.00
7	Behavioural + psychosocial	**1.25**	(1.08-1.43)	26	0.95	(0.84-1.08)	(-)67	**1.14**	(1.01-1.28)	30	1.00
8	Employment + behavioural + psychosocial	**1.19**	(1.03-1.37)	44	0.93	(0.82-1.06)	(-)133	**1.09**	(0.97-1.24)	55	1.00

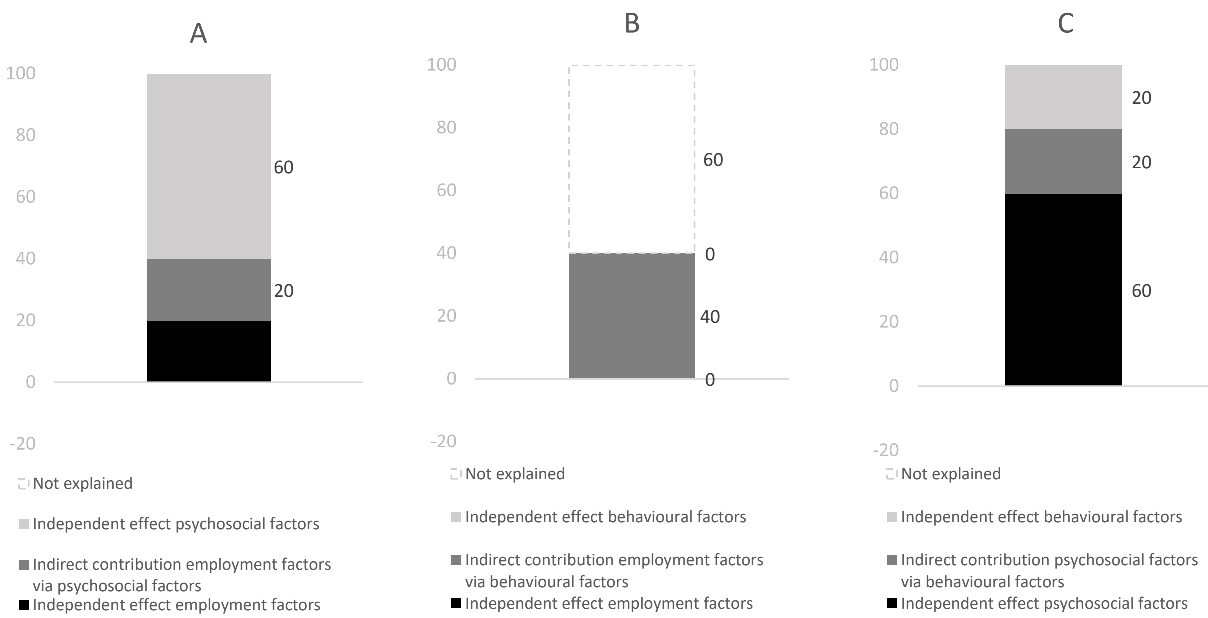
Values in bold does not include the OR 1.00.
Overlapping CI intervals indicates no statistically significant difference between groups.

Table 7: ORs and proportional change for poor self-reported health in age group 50+ by geographical affiliation

		Rural coast			Rural inland			Rural fjord			Urban coast
	Model	**OR**	**95% CI**	**Change**	**OR**	**95% CI**	**Change**	**OR**	**95% CI**	**Change**	**OR**
1	Gender	**1.67**	(1.53-1.82)		1.14	(1.06-1.23)		**1.27**	(1.19-1.37)		1.00
2	Employment	**1.58**	(1.44-1.72)	13	1.08	(1.00-1.17)	43	**1.21**	(1.12-1.30)	22	1.00
3	Behavioural	**1.54**	(1.41-1.68)	19	1.09	(1.01-1.17)	36	**1.24**	(1.15-1.33)	11	1.00
4	Psychosocial	**1.67**	(1.52-1.82)	0	1.09	(1.00-1.17)	36	**1.26**	(1.17-1.36)	4	1.00
5	Employment + psychosocial	**1.59**	(1.45-1.74)	12	1.04	(0.96-1.13)	71	**1.21**	(1.12-1.30)	22	1.00
6	Employment + behavioural	**1.50**	(1.37-1.64)	25	1.07	(0.99-1.16)	50	**1.20**	(1.11-1.30)	26	1.00
7	Behavioural + psychosocial	**1.55**	(1.42-1.70)	18	1.04	(0.96-1.13)	71	**1.23**	(1.14-1.33)	15	1.00
8	Employment + behavioural + psychosocial	**1.52**	(1.38-1.67)	22	1.03	(0.95-1.11)	79	**1.20**	(1.11-1.30)	26	1.00

Values in bold does not include the OR 1.00.
Overlapping CI intervals indicates no statistically significant difference between groups.

Figure 1: (A) Independent and indirect contributions of (A) employment factors and psychosocial factors, (B) employment factors and behavioural factors, and (C) psychosocial factors and behavioural factors to the explanation of the odds ratio of geographical categories. The urban coastal population is reference group.



Paper II

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Public health in restructuring coastal communities: Generational trends in self-rated health following the decline in small-scale fishing. The HUNT study, Norway

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ABSTRACT

Restructuring rural communities can be seen as natural population level experiments of great social epidemiological interest. Following the extensive decline in small-scale fishing in the later decades of the 20th century, many coastal communities have undergone considerable societal restructuring. In Norway, this has entailed a substantial reduction of the fishing workforce, concurrent with new employment opportunities in public sector and aquaculture. The former socialization into fishing from a young age is greatly reduced, with coastal youths now facing other life courses than preceding generations. As restructuring of societies is found to be intertwined with public health, coastal communities can provide valuable insights on public health during times of transitions. In this study, we use repeated cross-sectional population health data from rural Norwegian municipalities to assess the development of self-rated health over four decades in a coastal population who has undergone restructuring of local labour markets. We assess generational differences in health by comparing the prevalence of poor self-rated health at three ages reflecting three generations at each cross section: youths, adults and elderly. We compare results to adjacent geographical areas to assess geographical differences in self-rated health over time. We found a higher predicted prevalence of poor self-rated health in rural coastal adults and elderly compared to other geographical areas across all decades. However, trends revealed improving self-rated health in rural coastal adults and elderly, as well as narrowing health gaps between the rural coastal population and the remaining geographical areas in this Norwegian setting. Our results shed light on public health development in restructuring coastal communities.

1. Introduction

Following the later decades of the 20th century, many North European and North American coastal areas have faced a substantial decline in small-scale fishing (Olson, 2011; Pinkerton and Davis, 2015). Small-scale fishing has been a long-standing industry entangled with both social and economic relations of numerous coastal communities (Johnson et al., 2018; Urquhart et al., 2011), providing employment and survival for coastal inhabitants. Internationally, small-scale fishing is taking place in a wide range of waters, marine ecosystems and political arrangements (Smith and Basurto, 2019), and has traditionally included smaller vessels with low-tech gear, smaller crews and the support of whole households (Johnson et al., 2018). The observed decline in this industry has in many cases been spurred by regulations of fishing quotas and privatization of fisheries (Olson, 2011), resulting in considerable societal restructuring of afflicted areas.

This development is also apparent in Norwegian coastal areas. The Norwegian fishing fleet was previously characterized by open access without quota restrictions (Standal et al., 2016). The later decades of the 20th century entailed several major drops in fish stocks following a long

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period of overfishing, resulting in the introduction of quota regulations (Holm et al., 2015). This resulted in a substantial reduction of the Norwegian fishing fleet, where many workers with small vessels were no longer able to rely on fish supply for their livelihood (Christensen, 2014; Christensen and Zachariassen, 2014). For rural and small coastal communities with an established dependency on small-scale fishing, the downturn had substantial consequences; some Norwegian coastal communities were completely vacated, while others have endured out-migration and restructuring of local labour markets (Vik et al., 2011; Iversen et al., 2020). Fishing is now a livelihood for fewer people; the remaining vessels are fewer and bigger; and there has been an extensive technological development in fishing gear and catching (Sønvisen et al., 2011). Consequently, the inclusion of whole households in fishing-related activities and the socialization of young people into fishing are greatly reduced (Johnsen, 2004; Vik et al., 2011; Jentoft and Wadel, 1984).

Alongside the decline in small-scale fishing employment, Norway has experienced considerable growth in other areas of employment. The post-war era was a time of tremendous investments in the Norwegian public sector, with 80 percent of the national net increase in man-years between 1950 and 1980 taking place in the public service production (Mørk, 1984). The increase in public sector employment opportunities also benefitted rural areas in Norway, as this was a time of an increasingly active policy on upholding settlements in peripheral areas (Brox, 1980). Another emerging industry of the time was aquaculture, which has provided both employment opportunities and economic growth in many coastal communities. The collapses in fish stocks prompted many fishers to re-evaluate the possibilities of coastal resources. Investments in Norwegian fish farming were modest at first, but from the mid-1980s fish farming became a full-time job for many transitioning from the traditional fishing industry (Christensen and Zachariassen, 2014). In 2017, Norway was the second largest exporter of fish and fish products in the world (FAO, 2018). This have provided new opportunities of employment and income in many Norwegian coastal areas (Vik et al., 2011; Sønvisen et al., 2011; Christensen and Zachariassen, 2014).

In sum, Norwegian coastal areas have experienced several societal developments following the mid-20th century. To illustrate the greater trends over time, we present the developments in fishing activities and public sector employment in Norway from 1960 to 2017 below (Fig. 1).[1]

Restructuring of societies are found to be intertwined with public health (Stuckler et al., 2009), and societal conditions, social relations and community are rooted in a historical and cultural context which affects health behaviours and how health is perceived (Stephens, 2008). The transformations of Norwegian coastal communities can be considered natural experiments with potential impacts on the health of inhabitants, therefore being of great research interest. Former findings indicate that rural coastal populations with a history of small-scale fishing had higher odds of reporting poor self-rated health compared to other areas, hereunder both inland and other coastal-adjacent areas, after controlling for several compositional factors (Hjorthen et al., 2020). Still, it should be noted that the literature on health in fishery-based rural areas is scarce. There has been a growing interest in coastal health, with studies examining health effects of both biological aspects of marine life (Stewart et al., 2008), and social and emotional aspects of coastal living (Wheeler et al., 2012; White et al., 2013; Garrett et al., 2019; Pasanen et al., 2019), but the majority of existing research on coastal health does not target coastal communities with a history of small-scale fishing. Consequently, our knowledge about public health in coastal areas afflicted by a declining fishing industry and transitions to new industries is limited.

Economic and social changes operating over decades are found to be of larger importance for health than short-term policy interventions (Hanlon and McCartney, 2008). Therefore, potential changes in health during times of a decline in an important industry such as small-scale fishing should not be underplayed. Two main aspects of the Norwegian coastal restructuring are interesting in a health perspective. Firstly, the decline in small-scale fishing also entails a decline in dangerous working conditions for many coastal inhabitants. Small-scale fishing has historically been characterized by risk and hardship (Koren, 2017), with long hours, risk of injuries and vulnerability to weather conditions and stock fluctuations (Matheson et al., 2001; Petursdottir et al., 2001). Additionally, the lifestyle among fishers has been associated with both higher levels of smoking and alcohol intake (Koren, 2017; Thorvaldsen et al., 2016). Currently, fishing is a considerably less prevalent occupation, and coastal youth largely encounter formal schooling instead of primary socialization into local fishing crews (Vik et al., 2011).

Secondly, the detrimental decline in small-scale fishing has been followed by new and stable employment opportunities in both public sector and aquaculture. The decline in small-scale fishing undoubtably resulted in an extensive reduction in coastal-based livelihoods, potentially leaving people unemployed. The correlation between unemployment and poor health has been widely studied and confirmed (Abebe et al., 2016; Tøge and Blekesaune, 2015), also in countries with long-standing welfare services (Bambra and Eikemo, 2008). Unemployment has been found to negatively affect well-being, possibly resulting in poor physical health over time (Bartley et al., 2006; Korpi, 2001; Ytterdahl and Fugelli, 2000), in addition to long-term consequences for the displaced workers, with earning losses and worsened labour-market position exceeding the transitory period of adjustment (Eliason and Storrie, 2006). The concurrent rise in public sector employment opportunities, and later in aquaculture, could possibly buffer potential drops in public health during times of unemployment and economic recession.

The great shift from small-scale fishing to alternative employment opportunities and economic growth has likely gradually improved the general working conditions for many inhabitants in rural coastal areas. There is reason to believe that people growing up in rural coastal communities today face somewhat other life courses and employment opportunities than their preceding generations of parents and grandparents. On the same note, compared to previous generations, the current working age coastal population probably faces different working conditions, and the current elderly coastal population probably holds different working experiences. Although economic growth does not guarantee a progress in health (Tapia Granados and Ionides, 2008), the importance of life chances and employment opportunities for health have been thoroughly documented (McDade et al., 2011; Harris et al., 2002), which gives reason to anticipate an enhancement of public health in the surviving and restructured fishing- and coastal-involved areas. Compared to other geographical areas that have not experienced an equally sizeable decline in a local industry, one might anticipate differing trends in health over the same period, with a potentially eventual narrowing in favour of coastal areas as labour markets likely have become more similar across regions over time.

In this study, using repeated cross-sectional population health data from Norwegian municipalities, we assess the development of self-rated health over four decades in rural coastal areas with a history of small-scale fishing. In this examination of a coastal population who has faced both decline and development in local labour markets, we aim to assess generational differences in health by comparing the prevalence of poor self-rated health at three ages reflecting three generations at each cross section; youths, adults and elderly. This is an observational study aiming at describing generational trends in self-rated health during times of societal restructuring. Our analyses do not aim to demonstrate causality between societal restructuring and changes in health situation. Based on earlier findings and methods indicating poorer health in rural coastal areas compared to both inland and other coastal-adjacent areas (Hjorthen et al., 2020), we will compare results between rural coastal, urban coastal, inland and fjord areas to assess whether geographical

[1] Numbers derived from SSB (Statistics Norway) table 07811, 07842, 03214, 07326 and 09174, and NSD (Norwegian centre for research data).

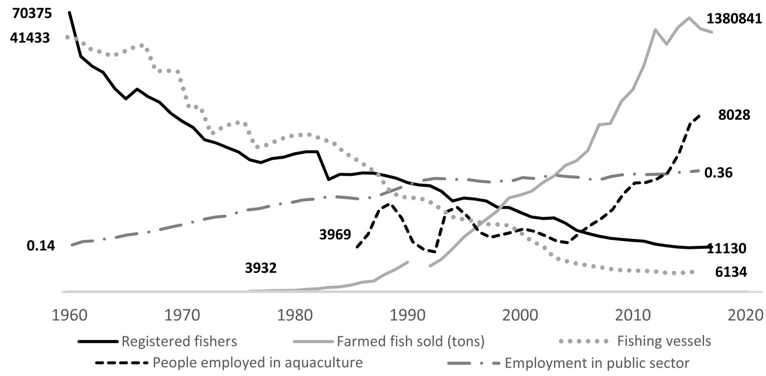

Fig. 1. Developments in registered fishers, vessels, farmed fish sold (tons), employment in aquaculture (persons) and public sector (public administration, education and health services) (portion of total employment). 1960–2017. Norway. All trends are presented together for illustrational purposes. Axes are not fixed or comparable.

differences in self-rated health are stable over time. With this study we aim to provide insights to health developments in rural coastal communities following the extensive international decline in small-scale fishing.

2. Methods

2.1. Data

Our study was based on data from the Trøndelag Health Study (HUNT), a Norwegian adult population-based cross-sectional health survey conducted four times in the now former county of Nord-Trøndelag: 1984–86 (HUNT1), 1995–97 (HUNT2), 2006–08 (HUNT3) and 2017–19 (HUNT4) (Krokstad et al., 2013). All county inhabitants of 20 years and older were invited to participate. The total participation in the four surveys was 89 %, 70 %, 54 % and 54 % of the invited population, respectively. The education and income level of the Nord-Trøndelag county were somewhat lower than the national Norwegian average, but the area was still considered representative of the overall Norwegian population (Krokstad et al., 2004). Because of missing data on self-rated health and municipality, we excluded 340 observations (0.4 %) from HUNT1, 525 (0.8 %) from HUNT2, 2219 (4.4 %) from HUNT3 and 2313 (4.1 %) from HUNT4. The final sample sizes were 76860 (HUNT1), 64703 (HUNT2), 48583 (HUNT3), and 53763 (HUNT4).

2.2. Geographical categorisation: rural coast, urban coast, rural inland and rural fjord

The Nord-Trøndelag county consisted of 24 municipalities, and in line with former findings (Hjorthen et al., 2020), these were classified into four geographical categories: rural coast, urban coast, rural inland and rural fjord. Characteristics of coastline and employment in fishing and aquaculture are found in Table 1. These numbers are collected from Statistics Norway, the Norwegian Centre for Research Data's (NSD) municipality database and the Norwegian Directorate of Fisheries. NSD and the Directorate of Fisheries are not responsible for analyses or interpretations in this study. The primary interest of this study is rural coastal areas with a history of small-scale fishing, and five municipalities fall under this category. These municipalities share three coastal characteristics: Firstly, they share a historically substantial proportion of employment in fishing. In 1960, before the major drops in fish stocks, these five municipalities had a considerable proportion of inhabitants with their main occupation in fishing, ranging from 10 to 27 percent, with a total at 17 percent for the area as a whole (NSD). The Nord-Trøndelag county has been an area characterized by small vessels and few fisheries employees (Hovland, 2014), and has close to no local employment in oil exploitation. Secondly, these municipalities have posed as long-standing coastal trading points (Herje, 1999), as they border to the big ocean instead of to the county fjord, and are therefore located by historical coastal shipping routes. Thirdly, the five municipalities have a low land-to-coast ratio, with a total area average of 0.46 km^2 land per km of coastline. This implies greater physical proximity to the coast for the inhabitants of these municipalities compared to other areas or municipalities of the county.

Five municipalities were classified as urban coastal areas. These municipalities are historical town areas. All urban coastal municipalities border to the coast, four of them in fjord areas, with an area total land-to-coast ratio of 6.39 km^2 land per km of coastline. The remaining rural municipalities were divided into two categories: rural fjord and rural inland. Both categories have no pronounced history of fishing (1.6 and < 1 percentage of the total workforce in 1960, respectively). Still, the fjord and inland categories differ significantly in land-to-coast ratio (4.88 km^2 and close to no coastline, respectively). Considering that former studies have revealed possible health effects of coastal proximity (Wheeler et al., 2012; White et al., 2013; Garrett et al., 2019; Pasanen et al., 2019), our study validity most likely benefits from differentiating between these areas.

The former county of Nord-Trøndelag has, as the total Norwegian nation, experienced a substantial decline in registered fishers and vessels, while experiencing a growth in aquaculture employment. The rural coastal areas, the region of interest in this study, have historically had a higher level of unemployment compared to the national level. After the millennium, this has changed. These changes are illustrated in Fig. 2.[2]

2.3. Measurement of health

The outcome of this study was self-rated general health. Self-rated health is a validated and widely used measurement of health; it has been shown to have strong predictive ability on mortality, morbidity and work-related disability (DeSalvo, 2006; Fosse and Haas, 2009; Schou et al., 2006). The original variable for self-rated health was for all surveys of The HUNT Study measured by the question "How is your health at the moment?" with four response alternatives: "Poor", "Not so good", "Good" and "Very good". All four surveys exhibited skewed distributions of this variable, with few respondents reporting "poor"

[2] Numbers derived from SSB (Statistics Norway) table 1603, 3214, 7811, 7842 and 11618 and NSD (Norwegian centre for research data).

Table 1
Coastline and coastal employment of the geographical categories. Former Nord-Trøndelag County, Norway.

	Km[b] land per km coastline (total)	Percentage of total employment in fishing (main occupation) 1960	Percentage of total employment in fishing (main occupation) 2017 HUNT4[a]	Employment in aquaculture[b] 2017 HUNT4 (County total)
Rural coast	0.46	17.2	2.8	519
Urban (coast)	6.39	<1	<0.1	
Rural inland	506.51	<1	<0.1	
Rural fjord	4.62	1.6	<0.1	

[a] Numbers based on register of Norwegian fishermen (main occupation), Norwegian Directorate of Fisheries.
[b] Employment in aquaculture not available om municipality level (see Fig. 1).

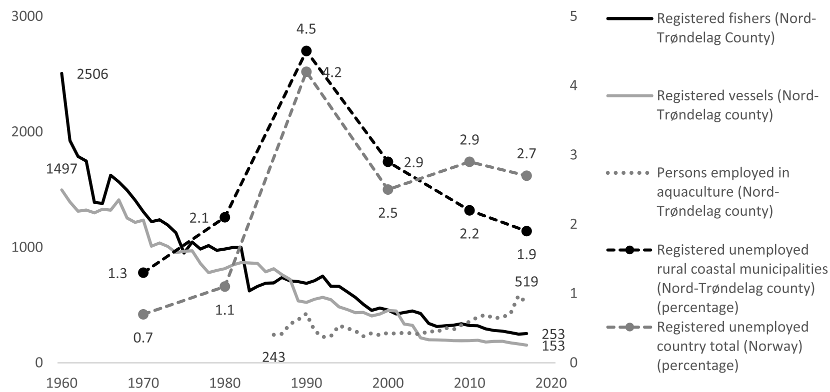

Fig. 2. Number of registered fishers, vessels and employees in aquaculture in the former Nord-Trøndelag County. Registered unemployment level in rural coastal areas compared to nation total, Norway. 1960–2017.

health. The variables were dichotomized, where the responses "Poor" and "Not so good" were merged into "Poor self-rated health", whereas the responses "Good" and "Very good" were merged into "Good self-rated health", functioning as the reference group.

2.4. Statistical analysis

For each HUNT cross-section, we fitted a Poisson regression model with robust variance estimates with poor self-rated health as the dependent variable and gender, age at participation (continuous) and geographical affiliation (rural coast set as reference) as predictors. The robust Poisson regression is recognised as an adequate method for handling binary outcomes, especially when the prevalence of the outcome is low and the model contains continuous covariates (Huang, 2019). Considering potential differing health trends between gender, generation and geographical affiliation between geographical categories, we estimated a three-way full-factorial regression model, allowing for interactions between all covariates. We tested each model with quadratic interactions of age, where Wald tests revealed statistically significant quadratic functions of age in all four models. Calculations showed that the vertex of the parabola lied outside the range of relevant values of age in all models. This means that the turning point of the curvilinear relationship between health and age does not lie within the relevant range of age (20–70 years).

From our regression models we estimated predicted prevalences of poor self-rated health at three ages (20, 45 and 70) for each geographical category. This method is known as adjusted predictions at representative values (APRs) (Williams, 2012) and for ease of communication we refer to them just as prevalences in the following. The ages 20, 45 and 70 years were chosen to reflect both generational divides in health and observed health at three different stages of life: young adulthood, working age and retired from the workforce. In addition, marginal effects (at representative values – MERs) of geographical affiliation were calculated at each age. Marginal effects provide an approximation to the amount of change in the outcome probability that will be produced by a one-unit change in an independent variable. In our study, the calculated marginal effects are the difference in the adjusted predictions for each geographical category (rural coast as reference), given the specific values of age. We also calculated marginal effects of gender contrasted between geographical categories (rural coast as reference) to test for statistically significant differences in effects of gender between the geographical categories. Both adjusted predictions at representative values and marginal effects at representative values were calculated using the margins postestimation command in Stata version 16. Changes in percent of prevalence and marginal effects of geographical affiliation from HUNT1 to HUNT4 is provided, and can be interpreted as how much of the gaps between the geographical categories and rural coast

Table 2
Change in inhabitants and registered employees* in total population from HUNT1 to HUNT4. Former Nord-Trøndelag County, Norway.

	HUNT1 1984–86	HUNT4 2017–19	Change
Rural coast			
Inhabitants	12927	11858	−8%
Registered employees	3456	5414	+57 %
Urban coast			
Inhabitants	78616	93389	+19 %
Registered employees	29881	43484	+46 %
Rural inland			
Inhabitants	17001	14968	−12 %
Registered employees	5565	6648	+19 %
Rural fjord			
Inhabitants	18167	17018	−6%
Registered employees	5780	7281	+26 %

*Statistics are derived from NSD and Statistics Norway, and do not include self-employment.

Table 3
Characteristics of the study population and prevalence of poor self-rated health in geographical areas. The HUNT Study 1–4.

	HUNT1	HUNT2	HUNT3	HUNT4
	1984–86	1995–97	2006–08	2017–19
Rural coast				
N	7981	6144	4230	4876
Mean age	51	51	54	54
Men (%)	49	47	45	46
Poor self-rated health (%)	36	35	34	30
Urban coast				
N	46378	40819	31282	35112
Mean age	49	49	53	54
Men (%)	48	47	46	45
Poor self-rated health (%)	25	26	24	23
Rural inland				
N	11142	8555	6421	6814
Mean age	50	52	54	56
Men (%)	51	48	47	47
Poor self-rated health (%)	25	27	26	25
Rural fjord				
N	11359	9185	6650	6961
Mean age	51	52	54	56
Men (%)	49	48	46	47
Poor self-rated health (%)	31	31	29	26
Total				
N	76860	64703	48583	53763
Mean age	49	50	53	55
Men (%)	49	47	46	45
Poor self-rated health (%)	27	28	26	24

(reference category) have changed.

3. Results

Table 2 shows the change in inhabitants and employment in the total population for all geographical categories from HUNT1 to HUNT4. Rural coastal areas have experienced the biggest increase (57 %) in registered employees of the geographical categories. Rural inland exhibits the largest decline (12 %) in inhabitants. Population statistics show that the total size of the working-age population in rural coastal areas has remained stable from the time of HUNT1 to HUNT4 (SSB, 2021a), indicating that a greater portion of the population is now employed compared to earlier. Table 3 shows general characteristics of the study populations in all surveys of the HUNT Study. There was no apparent skewness in age and gender between the geographical categories. The prevalence of poor self-rated health was highest in rural coastal areas in all surveys of the HUNT Study and overall lowest in the urban coastal areas.

Table 4 shows adjusted predictions of poor self-rated health for three generations from HUNT1 to HUNT4 for all geographical categories. Figs. 3 and 4 illustrate the development in prevalence and marginal effects of geographical affiliation, presented for each generation.

Youths in rural coast areas had the highest prevalence of poor self-rated health of the four geographical areas at HUNT1. Youths in urban coast had the highest prevalence of poor self-rated health at HUNT2, and rural fjord youths at HUNT3 and HUNT4 (Table 4, Fig. 3A). Youths of all geographical areas showed a substantial increase in poor self-rated

Table 4
Adjusted predictions of prevalence of poor self-rated health in three generations. 95 % confidence interval in parentheses. Marginal effects express the difference in the adjusted predictions between each geographical category and rural coast at the specified age value. Gender is an additional marginal effect contrasted between each geographical category and rural coast, significant differences in gender effects are assessed through confidence intervals. Total change expresses change from HUNT1 to HUNT4. Total change for marginal effects should be interpreted as either an increase or reduction of gaps between each geographical category and rural coast depending on the prefix."

	HUNT1	HUNT2	HUNT3	HUNT4	Total change
	1984–86	1995–97	2006–08	2017–19	
Rural coast					
Youths (20)	**5.2 (4.4, 6.1)**	**6.3 (5.1, 7.5)**	**7.9 (5.7, 10.0)**	**12.1 (9.8, 14.5)**	+133 %
Adults (45)	**27.3 (26.1, 28.6)**	**27.4 (26.1, 28.8)**	**24.0 (22.4, 25.6)**	**22.2 (20.8, 23.6)**	−19 %
Elderly (70)	**63.1 (61.2, 64.9)**	**57.6 (55.5, 59.7)**	**49.3 (47.0, 51.6)**	**39.7 (37.8, 41.7)**	−37 %
Urban (coast)					
Youths (20)	**4.5 (4.1, 4.8)**	**6.8 (6.3, 7.4)**	**8.1 (7.3, 9.0)**	**11.9 (11.0, 12.8)**	+164 %
Marginal effect	*−0.7 (-1.7, 0.2)*	*0.5 (-0.8, 1.9)*	*0.3 (-2.0, 2.6)*	*−0.2 (-2.7, 2.3)*	*(−)71 %*
Gender	*−1.2 (-3.0, 0.7)*	*−0.9 (-3.6, 1.8)*	*1.5 (-2.9, 6.0)*	*−0.3 (-5.3, 4.7)*	
Adults (45)	**19.7 (19.2, 20.1)**	**20.7 (20.2, 21.2)**	**18.8 (18.3, 19.4)**	**17.5 (17.0, 17.9)**	−11 %
Marginal effect	***−7.7 (-9.0, -6.4)***	***−6.7 (-8.2, -5.3)***	***−5.2 (-6.9, -3.5)***	***−4.8 (-6.3, -3.3)***	*(−)38 %*
Gender	*−0.6 (-3.2, 2.0)*	*0.8 (-2.0, 3.7)*	*0.8 (-2.6, 4.1)*	*0.0 (-2.9, 3.0)*	
Elderly (70)	**45.8 (45.0, 46.6)**	**42.9 (42.1, 43.7)**	**35.7 (34.9, 36.5)**	**29.7 (29.1, 30.4)**	−35 %
Marginal effect	***−17.3 (-19.3, -15.3)***	***−14.7 (-16.9, -12.4)***	***−13.6 (-16.0, -11.1)***	***−10.0 (-12.1, -8.0)***	*(−)42 %*
Gender	*−0.9 (-4.9, 3.1)*	*−1.3 (-5.8, 3.2)*	*0.7 (-4.3, 5.6)*	*−0.8 (-4.9, 3.3)*	
Rural inland					
Youths (20)	**4.1 (3.4, 4.8)**	**6.0 (4.9, 7.1)**	**5.7 (4.2, 7.2)**	**9.7 (7.8, 11.6)**	+137 %
Marginal effect	*−1.1 (-2.2, 0.0)*	*−0.3 (-2.0, 1.4)*	*−2.2 (-4.8, 0.5)*	*−2.5 (-5.5, 0.5)*	*(+)127 %*
Gender	*−1.9 (-4.1, 0.3)*	*0.9 (-2.5, 4.2)*	*2.0 (-3.1, 7.1)*	*−1.3 (-7.3, 4.6)*	
Adults (45)	**18.4 (17.5, 19.3)**	**20.7 (19.6, 21.8)**	**19.0 (17.7, 20.2)**	**16.6 (15.5, 17.6)**	−10 %
Marginal effect	***−9.0 (-10.5, -7.5)***	***−6.7 (-8.5, -5.0)***	***−5.1 (-7.1, -3.1)***	***−5.7 (-7.4, -3.9)***	*(−)37 %*
Gender	*−0.1 (-3.2, 2.9)*	*2.4 (-1.0, 5.8)*	*3.2 (-0.8, 7.2)*	*−0.1 (-3.6, 3.4)*	
Elderly (70)	**42.6 (41.1, 44.1)**	**42.3 (40.6, 44.0)**	**38.7 (36.9, 40.6)**	**31.8 (30.3, 33.4)**	−25 %
Marginal effect	***−20.5 (-22.8, -18.1)***	***−15.3 (-18.0, -12.6)***	***−10.5 (-13.5, -7.6)***	***−7.9 (-10.4, -5.4)***	*(−)61 %*
Gender	*1.8 (-2.9, 6.5)*	*−0.2 (-5.6, 5.2)*	*3.9 (-2.1, 9.8)*	*−0.7 (-5.6, 4.3)*	
Rural fjord					
Youths (20)	**4.8 (4.0, 5.5)**	**6.0 (4.9, 7.1)**	**9.5 (7.5, 11.6)**	**13.1 (10.7, 15.4)**	+173 %
Marginal effect	*−0.5 (-1.6, 0.7)*	*−0.3 (-1.9, 1.3)*	*1.6 (-1.3, 4.6)*	*0.9 (-2.4, 4.2)*	*(+)80 %*
Gender	*−0.6 (-2.8, 1.6)*	*−1.6 (-4.9, 1.6)*	*0.5 (-5.2, 6.3)*	*−2.3 (-8.8, 4.3)*	
Adults (45)	**22.3 (21.3, 23.2)**	**23.8 (22.7, 24.8)**	**21.5 (20.3, 22.8)**	**18.8 (17.7, 19.9)**	−16 %
Marginal effect	***−5.1 (-6.6, -3.5)***	***−3.7 (-5.4, -1.9)***	***−2.5 (-4.5, -0.5)***	***−3.4 (-5.2, -1.6)***	*(−)33 %*
Gender	*0.7 (-2.4, 3.8)*	*0.6 (-2.7, 4.1)*	*3.5 (-0.5, 7.5)*	*−1.8 (-5.4, 1.8)*	
Elderly (70)	**51.8 (50.3, 53.4)**	**49.9 (48.2, 51.6)**	**41.0 (39.2, 42.8)**	**32.3 (30.8, 33.8)**	−38 %
Marginal effect	***−11.3 (-13.6, -8.9)***	***−7.6 (-10.3, -5.0)***	***−8.3 (-11.2, -5.4)***	***−7.5 (-9.9, -5.0)***	*(−)34 %*
Gender	*1.3 (-3.5, 6.1)*	*1.1 (-4.3, 6.5)*	*4.9 (-0.9, 10.8)*	*−0.6 (-5.5, 4.3)*	

Values in bold have 95 % confidence intervals not including the value of 0.

health from HUNT1 to HUNT4, with the biggest change in rural fjord (+173 %), followed by urban coast (+164 %), rural inland (+137 %) and finally rural coast (+133 %). Marginal effects of geographical affiliation showed no statistically significant effects of geographical affiliation (rural coast set as reference) on poor self-rated health in youths across all decades, as all confidence intervals included the value of 0 (Table 4). The negative marginal effects of geographical affiliation, although not significant, increased considerably from HUNT1 to HUNT4 for both rural inland (+127 %) and rural fjord (+80 %), and decreased for urban coast (−71 %). This is shown as narrowing and increasing gaps between rural coast and the other geographical categories in Fig. 4A.

For adults, the rural coast areas had the highest prevalence of poor self-rated health of the four geographical areas for all surveys of the HUNT Study (Table 4, Fig. 3B). Adults of all geographical areas showed a decrease in poor self-rated health from HUNT1 to HUNT4, with the biggest change in rural coast (−19 %), followed by rural fjord (−16 %), urban coast (−11 %) and rural inland (−10 %). Marginal effects of geographical affiliation showed statistically significant negative effects of all geographical categories (rural coast set as reference) on poor self-rated health across all decades. Marginal effects of geographical affiliation laid between −7.7 and −4.8 for urban coast, −9 and −5.1 for rural inland and −5.1 and −2.5 for rural fjord (Table 4). In general, the negative marginal effects of geographical affiliation declined notably from HUNT1 to HUNT4 for all geographical categories: urban coast with −38 %, rural inland with −37 %, and rural fjord with −33 %. This is shown as narrowing gaps between rural coast and the other geographical categories in Fig. 4B.

For elderly respondents, the rural coast areas also here exhibited the highest prevalence of poor self-rated health of the four geographical areas for all surveys of the HUNT Study (Table 4, Fig. 3C). Elderly of all geographical areas showed a substantial decrease in poor self-rated health from HUNT1 to HUNT4, with the biggest change in rural fjord (−38 %), followed by rural coast (−37 %), urban coast (−35 %) and rural inland (−25 %). Marginal effects of geographical affiliation showed statistically significant negative effects of all geographical categories (rural coast set as reference) on poor self-rated health across all decades. Marginal effects of geographical affiliation laid between −17.3 and −10 for urban coast, −20.5 and −7.9 for rural inland and −11.3 and −7.5 for rural fjord (Table 4). Overall, the negative marginal effects of geographical affiliation for elderly declined notably from HUNT1 to HUNT4 for all geographical categories: urban coast with −42 %, rural inland with −61 %, and rural fjord with −34 %. This is shown as narrowing gaps between rural coast and the other geographical categories in Fig. 4C.

At all three ages, marginal effects for gender showed no statistically significant differences in gender effects between geographical categories on poor self-rated health, as all confidence intervals included the value of 0.

4. Discussion

In this study, using self-rated health perception as a measure of health, we aimed to examine and compare the development of health in youths, adults and elderly over four decades between four geographical areas, with emphasis on rural coastal areas with a history of small-scale fishing and recent restructuring of local labour markets. Across all four HUNT surveys, we found a higher prevalence of poor self-rated health in the rural coastal population compared to urban coast, rural inland and rural fjord populations, and a statistically significant higher prevalence of poor self-rated health in the rural coastal population in adults and elderly. Our results provide additional insights to former findings indicating a poorer health situation in rural coastal areas with a history of small-scale fishing compared to other areas (Hjorthen et al., 2020), by showing that these geographical differences persist over time.

The prevalence of poor self-rated health in rural coastal adults and elderly has decreased over the last four decades, whereas the prevalence

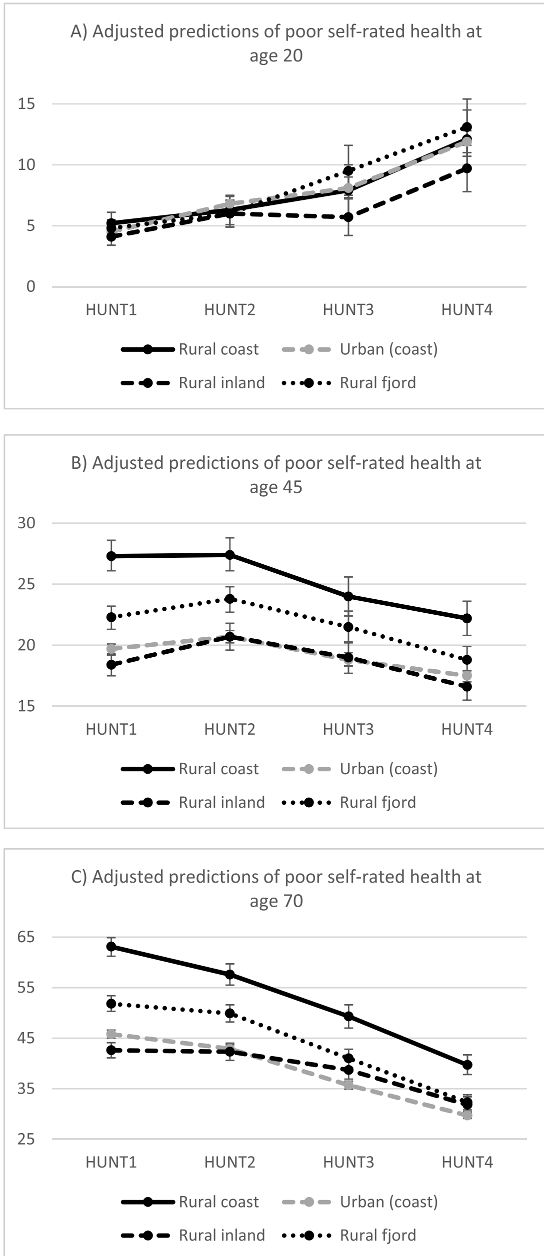

Fig. 3. Prevalence of poor self-rated health at age 20 (A), 45 (B) and 70 (C).

has substantially increased in rural coastal youths. These trends are also apparent in the remaining geographical categories, thus the overall trends of self-rated health in rural coastal areas seem to be in line with the general development in the total study population of the county. However, it should be noted that the rural coastal population exhibits the smallest increase in poor self-rated health in youths and the largest decrease in adults of the four geographical categories over time. Additionally, as anticipated, decreasing marginal effects indicate narrowing

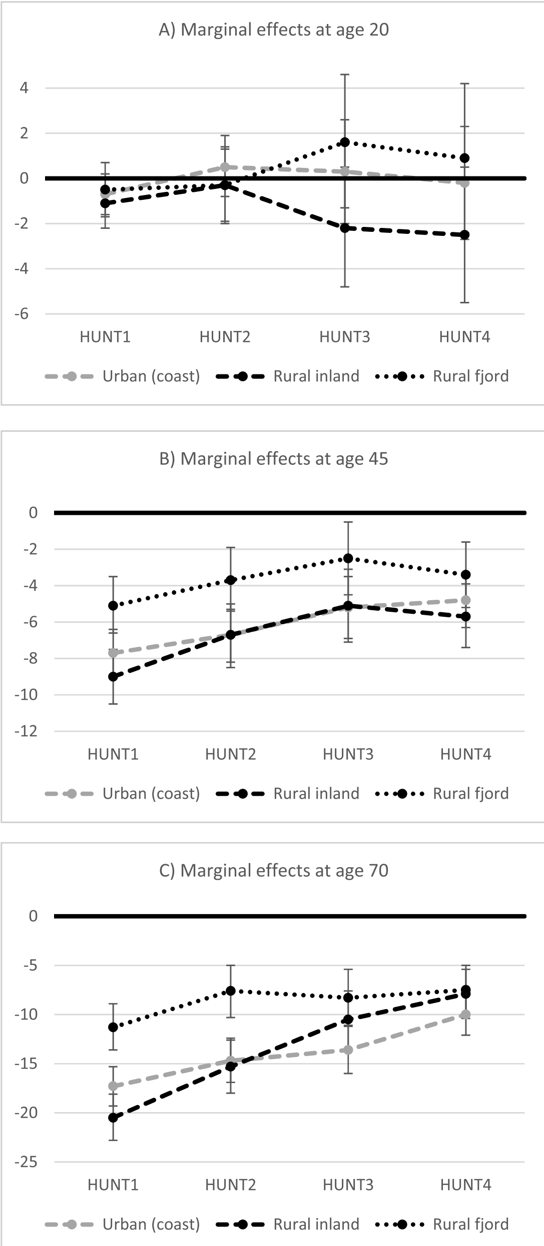

Fig. 4. Marginal effects of geographical affiliation on poor self-rated health at age 20 (A), 45 (B) and 70 (C). This shows the difference in the adjusted predictions for each geographical category. Rural coast set as reference.

gaps in self-rated health between the rural coastal population and the adjacent geographical areas in adults and elderly in this Norwegian setting.

The considerable increase in poor self-rated health in youths of all geographical categories reflects former findings indicating a wider trend of worsening of youth health and well-being, both in Norway, UK, and the United States (Bakken, 2019; Shah et al., 2019; Twenge et al., 2019). We found no statistically significant differences between the rural coastal population and the remaining geographical categories in youths across all four surveys of the HUNT Study. This lack of differences in youth health across geographical areas could be seen in light of the increasing and omnipresent impact of global discourses, independent of variations in rural coastal communities, producing particular images of successful modern self-hood and youth lifestyle. Contemporary modern societies have been described as characterised by increasing individualization processes and the emergence of more reflexive forms of identity construction (Giddens, 1991; Beck and Beck-Gernsheim, 2002). The growing pressure to succeed and match up to dominant ideals in several domains simultaneously impose a considerable psychological burden for young people in particular, often independent of geographical location, generating uncertainty and personal conflict with negative consequences for individual wellbeing (Perry 2009).

Considering general characteristics of coastal communities, such as physical isolation, low levels of employment and limited educational opportunities, which have been suggested to afflict coastal youths through harmful behaviours and an impairment of mental health (Cave, 2010), one could perhaps anticipate the burdens of increased individualization and identity construction to lay particularly heavy on rural coastal youth. Nevertheless, rural coastal youths exhibited a somewhat smaller increase in poor self-rated health compared to other areas. These variations between areas could be coincidental, but could potentially be seen in view of some rural coastal youths transitioning from an established track into a local and highly physical livelihood in fishing to prospects of employment in a wider range of industries (Vik et al., 2011; Sønvisen et al., 2011; Heggen et al., 2001). The new situation of several Norwegian rural coastal youths may have counteracted potential experiences of isolation and limited opportunities, possibly alleviating the general trend of worsening youth health.

We found statistically significant differences in self-rated health between the rural coastal population and the other geographical categories at both adult and elderly age across all four decades. Considering that we found no such differences in youths, our findings overall indicate that geographical inequalities in health emerge later in life. This could point to the importance of the local labour market in rural coastal areas, and that it perhaps has posed additional hazards to the overall health of the population compared to other geographical areas.

However, decreasing marginal effects of geographical affiliation in adults and elderly indicate that gaps in poor self-rated health between rural coastal areas and the other geographical areas have narrowed over time at these ages. Relatedly, our results showed that the rural coastal population exhibited the biggest decrease in poor self-rated health in adults over time of all areas. This improvement in self-rated health in the rural coastal population, especially in adults, can be assessed in light of the restructuring local labour market. At the time of HUNT1, the number of registered fishers and vessels were at their highest during the total span of HUNT data collection, but at a falling trend. The registered unemployment in the 1980's was also higher in rural coastal areas compared to the national average. As adults at 45 years were likely participants in the local labour market at the times of data collection, we can assume that this group were facing both the health hazards of fishing (Petursdottir et al., 2001; Matheson et al., 2001) and unemployment (Korpi, 2001; Bartley et al., 2006) in this phase of coastal labour market transitioning. This could potentially have put further health strains on the rural coastal workforce compared to other areas. This argument can also extend to the elderly rural coastal population, with many former participants in the local labour market, especially in fishing.

Over the course of the HUNT surveys the number of registered fishers in the county has kept falling. This considerable employment drop in fishing following the major stock crises, combined with technological developments in fishing gear and catching in the remaining fleet (Iversen et al., 2020; Sønvisen et al., 2011), may have lessened the total physical burden on the coastal workforce associated with fishing activity (Petursdottir et al., 2001; Matheson et al., 2001). The current occupation of fishing entails safer working condition, specialization and recruitment based on larger geographical areas (Sønvisen et al., 2011). Fishing is still an attractive occupation for some people, despite irregular working hours, periods away from home and changing income (Johnsen and Vik, 2013).

At the time of HUNT4, the registered unemployment in rural coastal areas had dropped well below the national level. As reported in the results, rural coastal areas have experienced the biggest increase in registered employees of the geographical categories, despite having a stable sized working-age population (SSB, 2021a). Over the decades following WW2, the national trend of great expansion in the Norwegian public sector has provided new employment opportunities, also in rural coastal areas. The rural coastal labour markets are have become more characterized by public services and private businesses (Vik et al., 2011), and women have explosively entered the labour market from the 1970s (Ellingsæter et al., 2020). Concurrently, accelerating from the mid-1980s, aquaculture has provided several coastal communities with both jobs and economic growth (Steinset, 2017). This trend is apparent in a variety of coastal areas around the world (Betcherman and Marschke, 2016; Nadarajah and Flaaten, 2017), and the former Nord-Trøndelag county has a noteworthy aquaculture activity (Trøndelag Fylkeskommune, 2018).

Earlier findings suggest that governments might be able to protect their populations from health hazards of economic downturns by providing employment opportunities for affected workers (Stuckler et al., 2009). Thus, the transition from a declining local industry to new employment opportunities in a more stable labour market may have been beneficial to the health of the working-age population in rural coastal areas. Correspondingly, social benefits provided through the Norwegian welfare state may have further lessened the potential health hazards of unemployment, as welfare generosity is found to be associated with lower risks of poor self-rated health during recessions (Abebe et al., 2016).

As most elderly respondents also have been a part of the rural coastal workforce, the narrowing gaps in poor self-rated health between rural coastal areas and the remaining areas in elderly indicate that this age group also may have benefitted from the restructuring of labour markets discussed above. Moreover, the narrowing health gaps in elderly could suggest that improvements in public health achieved from restructuring may have reached beyond the workforce itself. Former studies have found poor self-rated health in the general population to increase in correlation with economic crisis and rise in unemployment (Abebe et al., 2016; Astell-Burt and Feng, 2013). Considering that small-scale fishing in rural coastal communities often involved whole households in daily fishing-related activities, with families and communities relying on ocean resources (Jentoft and Wadel, 1984), the decline in fish stocks undoubtably affected the income and security beyond just the providing fisher at the time.

Relatedly, the one-income household structure has to a large extent been dissolved in Nordic countries, also in fishing communities (Vik et al., 2011). Our analyses indicated that the effects of gender on poor self-rated health in rural coastal areas do not significantly differ from the effects of gender in other geographical areas, at all three generations. This may indicate that the reorganization of local labour markets in rural coastal areas, with new employment opportunities in both public sector and aquaculture, might have benefitted self-rated health in both genders.

While we cannot precisely disentangle presumed effects, causalty or relative importance of labour market changes on self-rated health, there is reason to believe that they have contributed to the improvement of rural coastal health. The gaps in self-rated poor health between the rural coastal population and the other geographical areas in adults and elderly started narrowing from the first HUNT Study, during the decline in fishing and public sector investments, and before the greatest developments in aquaculture and fishing technology (Steinset, 2017; Sønvisen et al., 2011). This points to potential combined benefits of developments in both national and coastal-related labour markets on rural coastal health. And despite narrowing gaps between rural coastal areas and the other geographical categories in adults and elderly, it should be emphasized again that rural coastal areas still exhibit a higher prevalence of poor self-rated health compared to other areas at both ages.

4.1. Limitations

Some limitations with our study should be noted. Firstly, the situation of Norwegian rural coastal areas may not be fully generalized to other rural coastal areas. Norwegian rural coastal areas have seemingly benefitted from a national investment of public employment and the innovations in aquaculture and fishing. Accordingly, being a country with well-established welfare services, Norway might exhibit lessened impacts on health from unemployment and economic contractions or expansions compared to other countries. The effect of recession on wages might be weak, combined with generous social benefits (Shahidi et al., 2019). Therefore, one could anticipate other rural coastal areas not to have undergone identical restructuring of the local labour market following the international decline in small-scale fishing. Findings from UK indicate that coastal areas have lower rates of employment, where coastal employment tends to be revolved around low-skilled and highly seasonal labour (Depledge et al., 2017), suggesting that coastal communities not provided with growth in other sectors might have a more vulnerable workforce. There are also concerns that many potential growth sectors in marine technology may not be based in coastal areas (Morrissey, 2017). These factors should be considered in comparisons with other rural coastal areas.

Secondly, our observational study design does not provide conclusions on causal relationships between developments in rural coastal labour markets and self-rated health. Studies have suggested a two-way causality between unemployment and poor health (Tøge and Blekesaune, 2015; Kaspersen et al., 2016). We cannot conclude whether new employment opportunities have caused improved self-rated health directly, or furthermore: whether it has promoted the attraction and upholding of a healthier population. The increasing privileging of formal schooling and human capital formation globally is not without costs, emphasising more individualistic urban lifestyles and work careers, driving young people to leave rural areas (Gulløv and Gulløv, 2020). This is found also in coastal communities (Corbett, 2013). Relatedly, the cross-sectional design of this study does not exclusively follow the same sample, limiting the opportunity to examine changes at an individual or cohort level and factors included in such change. Nevertheless, the repeated cross-sectional design is beneficial in its ability to depict changes on an aggregate level by including every respondent at each cross-section. It should be noted that the response rate declined through the surveys of the HUNT Study. Still, the participation rate has declined in all municipalities, and a nonparticipant study following HUNT3 revealed no significant differences in poor self-rated health between participants and nonparticipants (Langhammer et al., 2012).

Thirdly, some aspects of the study area should be noted. Our study does not stratify on the different rural coastal municipalities. The emergence and development of aquaculture vary between rural coastal communities; not all have experienced the same growth in employment opportunities and societal benefits from this industry (Iversen et al., 2020). Therefore, there might be differences in health developments within the rural coastal population not detected in this study. Nonetheless, the rural coastal areas of this study exhibit work commuting between municipalities (SSB, 2021b), potentially enabling benefits of employment opportunities and economic growth across municipal boarders. Relatedly, potential migration is an often unknown factor when studying geographical disparities in health. Many Norwegian coastal communities faced a substantial outmigration in later half of the 20th century, where people often relocated to more urban areas (Sørlie, 1990; Myklebust, 2001). This type of relocation should still be expected in rural areas, but in a smaller scale. As selective migrants have been found to exhibit better health (Riva et al., 2011), we cannot rule out potential effects of these moves on population level health.

5. Conclusions

In this study, we calculated predicted prevalence of poor self-rated health at ages 20, 45 and 70 in four geographical categories over four decades. By differentiating between rural coast, urban coast, rural inland and rural fjord, we aimed to compare the health development of rural coastal areas with a history of declining small-scale fishing and subsequent restructuring of local labour markets to other areas. Our results show statistically significant higher prevalences of poor self-rated health in the rural coastal population at adult and elderly age across all surveys of the HUNT Study. Nonetheless, trends indicate improved self-rated health in rural coastal areas at these ages and narrowing health gaps to the remaining geographical area. In youths, the prevalence of poor self-rated health has increased substantially in all geographical categories, however, there were no statistically significant differences between geographical areas. While this study does not offer a conclusive answer to why rural coastal health is improving in adults and elderly, our results shed light on public health in restructuring coastal communities. This study shows that the general level of health has improved in a rural population enduring a substantial decline in one of its most crucial industries. This provides nuances to perceptions of deteriorating public health during times of crisis and emphasizes the potential importance of alternative and lasting local employment opportunities in smaller communities. Further research could benefit from exploring health developments in a wider variety of rural coastal communities facing the decline in small-scale fishing, as employment opportunities and welfare services vary considerably across nations. Our findings and geographical classification hopefully encourage reflections on the definition of coastal areas when assessing geographical inequalities in health. Furthermore, we suggest supplementary qualitative studies about perceived health and well-being across generations in coastal communities to attain more nuanced and in-depth knowledge about the topic of this study.

Credit author statement

Sofie L. Hjorthen: Conceptualization, Formal analysis, Writing - Original Draft, Erik R. Sund: Conceptualization, methodology, Writing - Review & Editing, Anne Trine Kjørholt: Writing - Review & Editing, Miriam Hjeldsbakken Engevold: Writing - Review & Editing, Steinar Krokstad: Conceptualization, Writing - Review & Editing, Supervision.

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Declaration of competing interest

None.

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Paper III

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Trends in absolute and relative educational inequalities in health during times of labour market restructuring in coastal areas: The HUNT Study, Norway

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A R T I C L E I N F O

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A B S T R A C T

Background: Restructuring labour markets offers natural population-level experiments of great social epidemiological interest. Many coastal areas have endured substantial restructuring of their local labour markets following declines in small-scale fishing and transitions to new employment opportunities. It is unknown how educational inequalities in health have developed in formerly fishery-dependent communities during such restructuring. In this study, we compare trends in social inequalities in health in Norwegian coastal areas with adjacent geographical areas between 1984 and 2019.
Methods: We used cross-sectional population-based data from the Trøndelag Health Study (HUNT), collected four times: HUNT1 (1984–86), HUNT2 (1995–97), HUNT3 (2006–08) and HUNT4 (2017–19). Adults above 30 years of age were included. Using Poisson regression, we calculated absolute and relative educational inequalities in self-rated health, using slope (SII) and relative (RII) indices of inequality.
Results: Trends in absolute and relative inequalities in rural coastal health were generally more favourable than in adjacent geographical areas. We found a statistically significant trend of declining relative educational inequalities in self-rated health in the rural coastal population from HUNT1 to HUNT4. Absolute inequalities overall increased from HUNT1 to HUNT4, although a declining trend followed HUNT2. Nonetheless, the rural coastal population exhibited the highest prevalence of poor self-rated health across the four decades.
Conclusions: Although absolute educational inequalities in self-rated health widened in all geographical areas, the smallest increase was in rural coastal areas. Relative educational inequalities narrowed in this rural coastal population. Considering the concurrent processes of large-scale investments in the Norwegian public sector and welfare schemes, increased fishing fleet safety, and employment opportunities in aquaculture, our findings do not suggest that potential positive effects on public health of this restructuring have benefitted inhabitants with higher educational attainment more than inhabitants with lower educational attainment in this rural coastal population.

1. Introduction

Restructuring labour markets, which can be considered a natural experiment at population level, is of great interest for social epidemiological studies. Because of the extensive restructuring of fisheries and their associated communities, coastal regions are of particular interest.

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Since the 1980s, there has been a substantial decline in small-scale fishing, a development particularly apparent in North European and North American coastal areas (Olson, 2011; Pinkerton and Davis, 2015). Coastal communities that formerly relied on ocean resources have faced major crises in fish stocks, with the subsequent downsizing of this long-standing industry and the loss of the livelihoods of many coastal inhabitants and families (Johnson, 2018; Urquhart et al., 2011). In many areas, the crisis has been accompanied by international neoliberal policy shifts in fishing, where privatisation and new quota distributions have threatened the sustainability of small-scale fisheries (Pinkerton, 2017; Pinkerton and Davis, 2015).

The decline in small-scale fishing has played a significant role in the general restructuring of Norwegian rural coastal areas since the mid-20th century. Following stock collapses and subsequent quota regulations that were introduced in the 1980s (Holm et al., 2015), some Norwegian coastal communities became completely vacated, while others experienced the substantial restructuring of the local labour market (Christensen, 2014; Iversen et al., 2020; Vik et al., 2011). Today, the remaining fishing fleet is small and technologically developed, consisting of fewer and bigger vessels with safer and more automized fishing gear (Sønvisen et al., 2011). Concurrent with the decline in small-scale fishing, Norway experienced several parallel societal developments: a general large-scale investment in the public sector, in which the biggest growth in public sector employment was between 1970 and 1980; a substantial increase in the level of education in all Norwegian regions (SSB, 2019a); the continuous strengthening of welfare schemes following the National Insurance Act of 1966 (Ellingsæter et al., 2020; Mørk, 1984); as well as booming marine industries, such as aquaculture and oil. These developments have resulted in the transformation of many coastal labour markets through new employment opportunities and welfare safety nets (Christensen and Zachariassen, 2014; Sønvisen et al., 2011; Vik et al., 2011).

Although economic restructuring of societies is intertwined with public health (Stuckler et al., 2009), we still do not know how periods of industrial transitioning associate with health inequalities in coastal populations. Previous studies have indicated that social inequalities in health increase during times of economic recession (Bacigalupe and Escolar-Pujolar, 2014), although Nordic welfare regimes are assumed to buffer against increasing social inequalities in health in deteriorating economies (Lahelma et al., 2002). For example, one study found that inhabitants of Norwegian rural coastal areas who previously relied on small-scale fishing reported poorer self-rated health compared with residents in adjacent urban, inland and fjord areas (Hjorthen et al., 2020). In the same rural coastal population, self-rated health has been found to overall improve from the 1980s to 2020, resulting in narrowing health gaps to adjacent areas (Hjorthen et al., 2021). Still, we know little about how the transformations in coastal labour markets may relate to changes in social inequalities in health, as trends in social inequalities in health in coastal areas following and during times of economic restructuring remain unstudied.

1.1. *Educational inequalities in health: the pathway of employment*

While current knowledge about social inequalities in health in restructuring coastal communities is limited, the relationship between social position and health has been thoroughly documented. Numerous studies have indicated that social position, especially educational level, is associated with a wide range of health indicators (Marmot, 2003). The gap in health between the top and bottom of the social hierarchy is not clearly delineated; rather, it follows a gradient, in which health improves as social position rises (Braveman and Gottlieb, 2014; Marmot, 2004). Social inequalities in health have been found to persist across European countries over the last decades, including in highly developed welfare states, such as the Nordic welfare regimes (Eikemo et al., 2008; Mackenbach et al., 2018). Following the millennium, prevalences of self-assessed morbidity have overall declined in European countries, in both men and women, irrespective of educational attainment. However, during the same period, the improvement in self-assessed morbidity was greatest among the highly educated, resulting in widening social inequalities in self-assessed health in European countries (Mackenbach et al., 2018). In the Western European countries most severely affected by the 2008 economic crisis, the trends in self-assessed health were less favourable (Mackenbach et al., 2018). Still, current knowledge on developments in educational inequalities in health in specific geographical regions, such as coastal areas, is limited.

Several theories about social determinants have been presented and debated in attempts to explain the association between education and health. Educational gradients have been found to be greater in high-preventable causes of morbidity and mortality (Mackenbach et al., 2015; Phelan et al., 2004; Rydland et al., 2020). This finding has been presented as evidence for socioeconomic status being the *fundamental cause* of inequalities in health through its embodied flexible resources such as money, knowledge, power, prestige and beneficial social connections (Link and Phelan, 1995). A frequently suggested social determinant and pathway concerns employment and working conditions. People with less formal education typically have fewer employment opportunities and lower expected wages, and are more vulnerable to economic fluctuations and subsequent unemployment and financial instability (Braveman and Gottlieb, 2014; Egerter et al., 2011). Numerous studies have documented the association between unemployment and poor physical health (Suhrcke and Stuckler, 2012), also within Scandinavian welfare state regimes (Bambra and Eikemo, 2009). Job insecurity, which often involves pessimism and a lack of financial security, has been found to be associated with poor self-rated health, as well as depression (Ferrie et al., 2005). Furthermore, workers with less formal education are more likely to hold jobs that include occupational hazards and poor working conditions, which puts them at higher risk of injury, illness and fatality (Egerter et al., 2011; Kaikkonen et al., 2009).

On an aggregated level, the restructuring of labour markets has likely entailed an overall shift in employment and working conditions in the rural coastal population, which was formerly comprised of many fishers and associated families with low educational attainment, hazardous working conditions, and vulnerability to sudden changes in ocean resources. However, the rural coastal population has increasingly become employed in the professionalised and largely non-manual public sector. Moreover, the great expansion in aquaculture since the mid-1980s has provided new occupations in manual labour, and the technological progress of the remaining fishing fleet has provided safer conditions for workers at sea, in contrast to the formerly hazardous occupations in small-scale fishing (Petursdottir et al., 2001; Sønvisen et al., 2011).

It remains unclear how educational inequalities in health have developed in formerly fishery-dependent communities during the process of restructuring. We do not know whether the restructuring of local labour markets has been accompanied by a widening in educational inequalities in health, which has been the general trend observed in European countries over the last decades (Mackenbach et al., 2018). Considering the pathway between working conditions and health, the decline and restructuring of a widespread, hazardous and vulnerable occupation traditionally conducted by coastal inhabitants of lower educational attainment may have altered the gap in health levels between inhabitants with lower and higher educational attainment in rural coastal areas. Therefore, we aim to examine the development in educational inequalities in health in rural coastal areas during decades of restructuring.

In this study, we examine trends in absolute and relative educational inequalities in self-rated health in a coastal area with a history of collapse in small-scale fishing and a transition to new industries, which can be considered a natural experiment at the population level. We use repeated cross-sectional population health data from Norwegian rural coastal municipalities, which were collected over four decades. In this observational study, we describe and discuss the development in educational inequalities in health against the backdrop of societal restructuring. Our methodological design does not aim to demonstrate causality between the restructuring of coastal labour markets and changes in educational inequalities in health. Based on earlier findings indicating poorer health in rural coastal areas compared with both inland and other coastal-adjacent areas (Hjorthen et al., 2020, 2021), in this study, we compare results from rural coast with urban coastal, inland and fjord areas to assess whether educational inequalities in self-rated health have developed differently between these geographical areas over time.

2. Methods

2.1. Study population

Our study was based on data from the Trøndelag Health Study (HUNT), a Norwegian adult population-based cross-sectional health survey conducted four times: 1984–1986 (HUNT1), 1995–1997 (HUNT2), 2006–2008 (HUNT3) and 2017–2019 (HUNT4) (Krokstad et al., 2013). All inhabitants 20 years and older in the now former county of Nord-Trøndelag were invited to participate. The total participation rates in the four survey rounds were 89%, 70%, 54% and 54% of the invited population, respectively. Nord-Trøndelag county has been found to have somewhat lower education and income levels compared to the national Norwegian average (Krokstad et al., 2004). Considering that the county does not constitute an extreme, in combination with the general government involvement in all Norwegian regions, we considered this population to be adequate for the purpose of studying trends in health.

The former Nord-Trøndelag County consisted of 24 municipalities. The primary interest of this study was rural coastal areas with a predominant history of small-scale fishing; five municipalities met this criterion. These municipalities share three coastal characteristics. Firstly, they have a substantial historical employment proportion of employment in fishing, which is mainly small-scale. In 1960, the proportions of employment in fishing ranged from about 10% to 27% of the total workforce in these municipalities, with an overall proportion of 17% for all five municipalities combined. In the remaining municipalities, employment in fishing was below 5% (NSD, 2020) (Data were obtained from the Norwegian Centre for Research Data's (NSD) municipality database. NSD is not responsible for analyses or interpretations in this study). Our definition of rural coastal municipalities is therefore in line with former analyses of fishery-dependent municipalities in Norway, which have operated with a cut-off of 5% employment in fishing (Iversen et al., 2016; Riksrevisjonen, 2020). Secondly, these five municipalities border an ocean, and they have provided long-standing coastal trading points along historical coastal shipping routes (Herje et al., 1999). Thirdly, the five municipalities have a low land-to-coast ratio, with an area average of 0.46 km^2 land per km of coastline, which implies greater physical proximity to the coast for the inhabitants of these municipalities compared with other areas or municipalities in the county.

Data on rural coastal areas have been compared with data on the

Table 1
Unadjusted characteristics of the study samples from the HUNT Study, Norway. Adult population 30+.

	HUNT1 (1984–86)	HUNT2 (1995–97)	HUNT3 (2006–08)	HUNT4 (2017–19)
Rural coast				
Response rate	90.4	68.9	52.6	55.6
Final N	6670	5363	3928	4363
Prevalence of poor self-rated health	2801 (42)	2096 (39.1)	1395 (35.5)	1404 (32.2)
Missing self-rated health	37 (0.6)	29 (0.5)	149 (3.7)	77 (1.7)
Educational level				
Primary	4776 (71.6)	2921 (54.5)	1111 (28.3)	795 (18.2)
Secondary	849 (12.7)	1712 (31.9)	1741 (44.3)	2209 (50.6)
Tertiary	340 (5.1)	615 (11.5)	804 (20.5)	1341 (30.7)
Missing	705 (10.6)	115 (2.1)	272 (6.9)	18 (0.4)
Urban (coast)				
Response rate	87.8	68.7	52.2	51.8
Final N	38710	34723	28366	31748
Prevalence of poor self-rated health	11115 (29)	9903 (28.5)	7366 (26.0)	7766 (24.5)
Missing self-rated health	174 (0.5)	364 (1)	793 (2.7)	474 (1.5)
Educational level				
Primary	22253 (57.5)	13687 (39.4)	4979 (17.6)	3480 (11)
Secondary	8218 (21.2)	13611 (39.2)	12502 (44.1)	14675 (46.2)
Tertiary	4123 (10.7)	6940 (20)	8817 (31.1)	13494 (42.5)
Missing	705 (10.6)	485 (1.4)	2068 (7.3)	99 (0.3)
Rural inland				
Response rate	93.1	71.2	62.88	63
Final N	9287	7471	5950	6210
Prevalence of poor self-rated health	2651 (28.6)	2200 (29.5)	1656 (27.8)	1633 (26.3)
Missing self-rated health	69 (0.7)	39 (0.5)	284 (4.6)	120 (1.9)
Educational level				
Primary	6199 (66.8)	3679 (49.2)	1436 (24.1)	992 (16)
Secondary	1657 (17.8)	2656 (35.6)	2779 (46.7)	3035 (48.9)
Tertiary	597 (6.4)	1083 (14.5)	1456 (24.5)	2165 (34.9)
Missing	834 (9)	53 (0.7)	279 (4.7)	18 (0.3)
Rural fjord				
Response rate	91.5	71.9	54.6	56.8
Final N	9682	8096	6158	6442
Prevalence of poor self-rated health	3346 (34.6)	2752 (34)	1898 (30.8)	1749 (27.2)
Missing self-rated health	19 (0.2)	31 (0.4)	227 (3.6)	107 (1.6)
Educational level				
Primary	6262 (64.7)	3840 (47.4)	1423 (23.1)	942 (14.6)
Secondary	1775 (18.3)	3008 (37.2)	2850 (46.3)	3290 (51.1)
Tertiary	756 (7.8)	1180 (14.6)	1509 (24.5)	2194 (34.1)
Missing	889 (9.2)	68 (0.8)	376 (6.1)	16 (0.3)

remaining population of the county. Similar to previous studies (Hjorthen et al., 2020, 2021), the remaining municipalities were classified into three geographical categories: urban coast, rural inland and rural fjord. Five municipalities were classified as urban coastal areas. Historically, these municipalities comprise town areas. All urban coastal municipalities border the coast, four of which are in fjord areas, with an area total land-to-coast ratio of 6.39 km^2 land per km of coastline. The two remaining categories, rural inland municipalities (eight municipalities) and rural fjord municipalities (from six to five municipalities at HUNT 4 because of municipality mergers), have no pronounced history of fishing (1.6 and < 1% of the total workforce in 1960, respectively). However, the fjord and inland categories differed significantly in land-to-coast ratio (with 4.88 km^2 and no coastline, respectively). Considering that previous studies have revealed potentially positive effects of coastal proximity on residents' health (Wheeler et al., 2012; White et al., 2013), the validity of our study was likely strengthened by differentiating between these two areas.

We limited our analyses to data on participants aged 30 years or older to ensure the attainment of education. Educational attainment was requested in all HUNT surveys except HUNT3. If the respondents had participated in several surveys in the HUNT Study, any missing data on educational level were imputed if available. The remaining missing regarding education were handled through multiple imputation in all four surveys. Following methodological recommendations, available responses on all variables were included in the imputation modelling, including the dependent variable of self-rated health (Von Hippel, 2007). Respondents with missing values of self-rated health were then excluded from the final analyses, as there were few missing cases (all below 5%) and therefore unlikely to introduce bias (Jakobsen et al., 2017). The final sample sizes and missing responses on self-rated health in each geographical category are presented in Table 1.

2.2. Measurement of health

The outcome in this study is self-rated general health, which is a widely studied and validated measurement of health that has been shown to have strong predictive ability regarding mortality, morbidity and work-related disability (DeSalvo et al., 2006; Fosse and Haas, 2009). In the HUNT Study, the original variable of self-rated general health was measured by the question "How is your health at the moment?" with four response alternatives: "Poor", "Not so good", "Good" and "Very good". The responses "Poor" and "Not so good" were merged into "Poor self-rated health", while the responses "Good" and "Very good" were merged into "Good self-rated health", functioning as a reference category.

2.3. Educational level

Educational level was chosen as the indicator of socioeconomic position in this study. Educational level is a stable measurement which is attained early, and is also maintained if respondents have left the labour market. The original set of variables on educational level consisted of eight (HUNT1), five (HUNT2) and six (HUNT4) categories, which were collapsed into three levels based on the educational classifications of ISCED11 and NUS 2000 (Barrabés and Østli, 2016): primary (primary and lower secondary school), secondary (upper secondary and post-secondary school) and tertiary (first and second stage of tertiary education).

2.4. Statistical analysis

Age-standardised prevalences of poor self-reported health were calculated using 10-year age groups, using the direct method and only available observations. The standard population used in the standardisation was the total population of Nord-Trøndelag County aged 30 years or older on January 1st, 2000. A standard population based on the total population, in contrast to disaggregation by gender, enables the comparison of prevalences between genders (Pace et al., 2013). Analyses stratified by gender are available in the supplementary material.

Educational inequalities in self-rated health were measured using the slope index of inequality (SII) and the relative index of inequality (RII). These are regression-based absolute and relative measurements of inequalities in health, providing absolute and relative differences in the prevalence of outcomes between respondents with the lowest and highest educational level (Regidor, 2004). Absolute measures, such as SII, are sensitive to changes in the frequency of the health problem being studied, which limits comparisons of socioeconomic inequality in health across populations or over time (Regidor, 2004). By also calculating RII, we achieve a better assessment of educational inequalities in self-rated health across the four rounds of the HUNT surveys. Educational levels were assigned a ridit score ranging from 0 (highest level of education) to 1 (lowest level of education). The ridit score was based on the midpoint of the range in the cumulative distribution of the population of participants in the given category. Values of SII greater than 0 and RII values greater than 1 indicate that the outcome is more prevalent among individuals with lower education than among individuals with higher education.

Both SII and RII were calculated using robust Poisson regression with identity and log link functions, respectively. Poisson regression is considered an adequate method for handling binary outcomes, especially when the prevalence is low and the model contains continuous covariates (Chen et al., 2018; Huang, 2019). Multiple imputation was used. The SII can be interpreted as prevalence differences, whereas the RII can be interpreted as prevalence ratios. SII and RII were obtained by regressing self-rated health on the ridit-score. All models were adjusted for age and gender and estimated with 95% confidence intervals. Estimations were calculated separately for each HUNT survey. Trends were assessed by pooling the four surveys and including a two-way interaction term ridit score by survey, as done by Ernstsen et al. (2012) and Mondor et al. (2018). Similarly, to test for gender differences in RII and SII at each survey, we included a two-way interaction term ridit score by gender at each survey. To test for gender differences in RII and SII trends over time, we included a three-way interaction term ridit score by gender by survey (Ernstsen et al., 2012).

3. Results

Unadjusted prevalence of poor self-rated health decreased from HUNT1 to HUNT4 in all geographical categories. Educational level increased over time in all geographical categories, leaving primary education the smallest group in all categories at HUNT4 (Table 1). The age-standardised prevalence of poor self-rated health in all educational groups was the largest in the rural coastal population compared with all other geographical regions at both HUNT1 and HUNT4. Age-standardized prevalences increased from HUNT1 to HUNT4 in all education groups in all geographical categories, except for tertiary education in the rural fjord population (Table 2).

The rural coastal population exhibited the largest absolute (SII) educational inequalities in self-rated health compared with all other geographical regions at HUNT1. The absolute inequalities in rural coastal areas increased from HUNT1 to HUNT2 and decreased from HUNT2 to HUNT4. The test for trend indicated a statistically significant trend of narrowing absolute inequalities ($p < 0.001$) (Fig. 1). Stratified analyses showed that rural coastal men exhibited a substantial decline in absolute inequalities, while rural coastal women exhibited a substantial increase (Supplementary material, Tables 1 and 2). All geographical regions exhibited increased absolute educational inequalities in health (SII) at HUNT4 compared with HUNT1. The smallest increase was in the rural coastal population (19.7%), and the biggest increase was in the rural fjord population (83.7%). At HUNT4, absolute educational inequalities in self-rated health in the rural coastal areas were smaller than in the rural fjord areas.

Table 2
Age-standardised prevalence of poor self-rated health and absolute (Slope index of inequality, SII) and relative (Relative index of inequality, RII) educational inequalities (95% CI in brackets) in poor self-rated health. The HUNT Study, Norway. Adult population 30+.

	HUNT1 (1984–86)	HUNT2 (1995–97)	HUNT3 (2006–08)	HUNT4 (2017–19)	Change HUNT1-HUNT4	P for trend
Rural coast						
Primary	41.6	43.2	43.0	43.4		
Secondary	27.6	32.3	31.6	31.5		
Tertiary	21.7	24.9	24.9	23.6		
SII	19.19 (13.65–24.73)	26.10 (20.58–31.62)	24.61 (18.28–30.93)	22.95 (17.54–28.36)	+19.7%	**<0.001**
Gender*	0.673	0.996	0.090	**0.005**		**0.022**
RII	2.68 (2.09–3.43)	2.41 (2.01–2.88)	2.17 (1.80–2.62)	2.07 (1.73–2.48)	−22.8%	**<0.001**
Gender*	0.575	0.065	0.265	0.252		0.158
Urban (coast)						
Primary	31.0	35.1	36.4	39.1		
Secondary	23.1	26.8	26.1	26.2		
Tertiary	16.3	20.2	18.8	18.5		
SII	14.03 (12.14–15.93)	19.62 (17.78–21.47)	19.52 (17.35–21.69)	20.71 (18.91–22.52)	+47.6%	**<0.001**
Gender*	0.597	0.498	0.138	0.104		0.495
RII	2.30 (2.09–2.53)	2.15 (2.00–2.33)	2.10 (1.93–2.29)	2.30 (2.12–2.48)	0%	**<0.001**
Gender*	0.094	**<0.001**	**<0.001**	**0.023**		0.361
Rural inland						
Primary	28.7	32.6	32.0	32.2		
Secondary	18.7	26.4	26.2	25.4		
Tertiary	14.7	17.4	20.1	19.3		
SII	11.77 (7.73–15.81)	18.21 (13.81–22.61)	20.00 (15.13–24.86)	16.99 (12.72–21.26)	+44.4%	0.865
Gender*	0.434	0.219	0.218	0.194		0.898
RII	2.44 (1.95–3.06)	2.11 (1.78–2.49)	1.99 (1.65–2.38)	1.86 (1.57–2.21)	−23.8%	**0.002**
Gender*	0.948	0.800	**0.013**	0.380		0.427
Rural fjord						
Primary	34.8	36.9	42.6	39.2		
Secondary	25.3	31.3	29.1	28.2		
Tertiary	19.3	21.0	21.2	18.0		
SII	12.94 (8.63–17.25)	19.45 (15.01–23.88)	22.51 (17.63–27.38)	23.77 (19.56–27.98)	+83.7%	0.104
Gender*	0.520	0.303	0.234	0.060		**0.041**
RII	2.22 (1.84–2.67)	1.97 (1.70–2.27)	2.04 (1.73–2.40)	2.43 (2.06–2.87)	+9.5%	0.128
Gender*	0.837	**0.049**	0.816	0.249		0.924

*P-values of interaction term.
Values in bold indicate p-values <0.05.

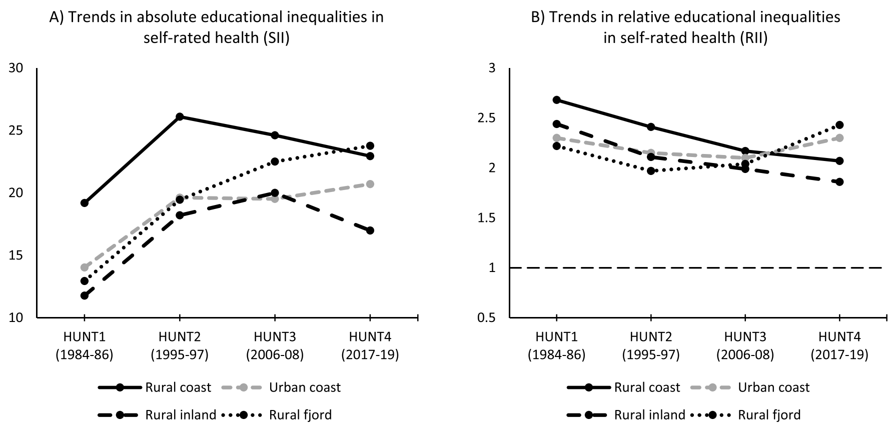

Fig. 1. Trends in slope index of inequality (SII) and relative index of inequality (RII) in poor self-rated health in the rural coastal, urban coastal, rural inland and rural fjord population from HUNT1 (1984–86) to HUNT4 (2017–19), the HUNT Study Norway.

The rural coastal population exhibited the largest relative (RII) educational inequalities in self-rated health compared to all other geographical regions at HUNT1. Relative inequalities decreased steadily in the rural coastal population from HUNT1 to HUNT4, and test for trend showed a statistically significant trend of narrowing relative inequalities ($p < 0.001$) (Fig. 1). Stratified analyses show rural coastal men to exhibit a substantially larger decline in relative inequalities compared to rural coastal women (Supplementary material, Tables 1 and 2). This was also the case in the rural inland population ($p = 0.002$). The urban coast and rural fjord population exhibited an initial decrease in relative educational inequalities in self-rated health following HUNT1, but they exhibited relative inequalities at HUNT4 equal to and higher than at HUNT1, respectively. At HUNT4, relative educational inequalities in self-rated health in rural coastal areas were smaller than in rural inland and rural fjord areas.

Test for gender differences at each survey revealed statistically significant differences between genders only in SII at HUNT4 in the rural coastal population, where men exhibited smaller absolute inequalities in poor self-rated health compared with women (p = 0.005) (Table 2). Regarding the remaining geographical regions, gender differences were found in RII at HUNT2, HUNT3 and HUNT4 in the urban coastal population and at HUNT2 in the rural fjord population. Gender differences in trends were found in the rural coastal population (p = 0.022) and in the rural fjord population (p = 0.041), where the development in absolute inequalities over time was significantly smaller for men compared to women.

4. Discussion

In this study, we examined absolute and relative educational inequalities in self-rated health over four decades in a rural coastal population that has faced a substantial restructuring of its local labour market, particularly in relation to declines in small-scaled fishing, in a Norwegian welfare state setting.

We found statistically significant trends of declining absolute and relative educational inequalities in self-rated health in this rural coastal population. Relative educational inequalities declined steadily from HUNT1 to HUNT4, while absolute educational inequalities declined following an initial increase from HUNT1 to HUNT2. This resulted in larger absolute educational inequalities at HUNT4 compared with HUNT1. Overall, our findings indicate narrowing educational inequalities in health during a period of labour market restructuring. Our findings suggest that rural coastal inhabitants with higher educational attainment have not benefitted more greatly health-wise from the societal restructuring, despite this being a period characterized by the loss of primary sector livelihoods and a substantial increase in professionalised employment opportunities in public sector. The educational level in this rural coastal population increased over the survey period, leaving the lowest educational group the smallest at HUNT4. This was expected, as the general level of education has increased in the total Norwegian population over the same period (SSB, 2019a). The findings showed that age-adjusted prevalences of poor self-rated health in both the lowest and highest educational levels were fairly stable, which was somewhat unexpected because of the substantial change in the distribution of these groups.

As we are not aware of similar studies on developments in educational inequalities in self-rated health in rural populations experiencing substantial restructuring of their local labour market, the comparison of our findings with existing literature is limited. Similarly, existing literature limits comparisons with restructuring coastal areas with less generous or absent welfare schemes. Still, widening or overall stable absolute educational inequalities in self-assessed health have been observed in European countries over the last decades (Hu et al., 2016; Mackenbach et al., 2018). Moreover, our findings from this rural coastal population add nuances to the findings of larger national and cross-national studies pointing to a general trend of persisting or widening relative educational inequalities in self-assessed health in Western Europe (Hu et al., 2016; Mackenbach, 2012; Mackenbach et al., 2018).

Compared with the other geographical areas of the county, the rural coastal population exhibited a decrease in relative education inequalities in self-rated health, which was matched only by the rural inland population. The rural coastal population changed from exhibiting the largest relative educational inequalities in self-rated health at the first HUNT survey to exhibiting smaller relative inequalities compared with both the rural fjord and urban coast populations at the fourth HUNT survey.

In all geographical areas examined in this study, absolute inequalities in self-rated health were greater at HUNT4 compared with HUNT1. Although changes in absolute inequalities in health are overall less emphasized compared to relative inequalities in health literature, the importance of monitoring their development has been advocated (Houweling et al., 2007; Mackenbach, 2015). Ignoring absolute measures incurs the risk of overlooking developments in overall population health and in the absolute rates of disease for each group (Harper et al., 2010). The increase in absolute educational inequalities in self-rated health could indicate that inequality is worsening, which is often caused by a greater absolute increase in the rate of poor health of the disadvantaged (Harper et al., 2010). The initial increase in absolute inequalities in rural coastal areas could be seen in light of a great decline in cod-fishing in the late 1980s (Bjørndal et al., 2004). However, our findings indicate that this was a general development in Norwegian society at the time. Overall, the rural coastal areas exhibited the smallest increase in absolute inequalities among the four geographical regions, and the results of the stratified analyses showed a decrease among rural coastal men. This finding indicates that although the prevalence of poor self-rated health in all educational groups increased in rural coastal areas during this period, they increased at more similar rates compared with the remaining geographical regions. Considering the age-adjusted prevalences, rural coastal inhabitants with primary education exhibited a smaller increase in the prevalence of poor self-rated health compared with inhabitants with primary education in the remaining areas. Rural coastal inhabitants with tertiary education exhibited a higher prevalence of poor self-rated health compared with the tertiary groups in the remaining areas.

Although it showed the largest prevalence of poor self-rated health among the four geographical regions, the development of educational inequalities in health was generally more favourable in the rural coastal population compared with the remaining areas in the county. In light of the potential pathway of employment in educational health inequalities, the narrowing relative educational health gap in rural coastal areas, as well as the smaller widening in absolute inequalities compared to the remaining county, can suggest that differences in employment-related health hazards have decreased between educational groups in this rural coastal population. In contrast to the remaining areas in the county, rural coastal areas have experienced labour market shifts that are strongly linked to the downturn and transformation of a local and coastal-based industry. This transformation has likely entailed a narrowing gap in working conditions and economic vulnerability between manual and professionalised non-manual jobs. Although our analysis does not prove causality between the labour market restructuring and narrowing educational inequalities in health, our findings can suggest that the general shift in employment conditions may have contributed to the narrowing in relative educational inequalities in health. And although the pathways linking educational level and health are complex and highly debated (Braveman and Gottlieb, 2014), our findings provide insights into the potential effects of working conditions on the relation between educational levels and inequalities in health (Egerter et al., 2011), suggesting that this pathway may be affected by structural changes in society.

Correspondingly, the role of welfare expenditures should be emphasized. In Norway, the established welfare services, which were strengthened during the same period as the restructuring of fishing industries (Ellingsæter et al., 2020), might have benefitted groups leaving manual coastal occupations because of unemployment or work-related injuries. Because welfare benefits are found to lessen the potential health hazards of economic recession and unemployment (Abebe et al., 2016; Stuckler et al., 2009), rural coastal inhabitants affected by the decline in small-scale fishing have likely benefitted from extensive social expenditures. Nonetheless, public spending does not guarantee educational equality in health. Although Nordic welfare regimes have been assumed to buffer the growth in social inequalities in health rates during times of economic recession (Lahelma et al., 2002), they have not been found to outperform other European welfare regimes in preventing social inequalities in health (Eikemo et al., 2008).

Our findings should also be considered in the context of the study area. Central Norway is a region with some of the lowest educational inequalities in daily smoking, physical activity and alcohol consumption on both relative and absolute scales (Elstad and Koløen, 2009). Findings from previous research on this study population have indicated decreasing relative educational inequalities in self-rated health in the total county population (Krokstad et al., 2002), where levels of inequality have been shown to be lower than the national average (Mackenbach et al., 1997). The lack of a big city in the region has been presented as a possible explanation (Krokstad et al., 2002), as larger cities typically demonstrate greater inequalities compared with rural areas (Elstad and Koløen, 2009). Considering the rurality of our study area, smaller inequalities in rural coastal areas compared to both national and European averages are expected.

We found no statistically significant differences in relative inequalities in self-rated health between genders in the cross-sectional and trend results. We found a statistically significant trend of smaller absolute educational inequalities in men compared with women over time in the rural coastal and rural fjord areas. In sum, these findings give no clear reason to suggest that the transformation of rural coastal local labour markets has benefitted one gender over the other. During the decades spanned by the HUNT Study, more women entered the labour market (Ellingsæter et al., 2020; SSB, 2019b) and were likely to have benefitted from the national investment in the public sector in rural areas.

4.1. Limitations

Some limitations of our study should be noted. Firstly, education was used as a proxy for socioeconomic status. Alternatively, considering the pronounced egalitarian nature of Norwegian society, occupational class might be an adequate measure of social position or placement in the occupational hierarchy (Elstad and Koløen, 2009). Social class based on occupation is often shaped by the local labour market (Macintyre et al., 2002), and it may provide a suitable measure of socioeconomic status in rural areas. Nevertheless, information about former occupations was not collected in all HUNT surveys, excluding participants who had left the labour because of retirement or illness. Moreover, only one occupation was registered per participant, which potentially left out information on former and long-lasting occupations. Considering the stability, early attainment, and extensive research on educational inequalities in health, the use of educational level as a proxy for socioeconomic status provided more opportunities for comparisons both over time and with the findings of similar studies.

Secondly, some aspects of the rural coastal study population should be commented. Based on a total population study, our results reflected the development of educational inequalities in health in entire communities, not only in those inhabitants directly affected by the restructuring of labour markets. Nonetheless, many rural coastal inhabitants were probably directly or indirectly affected by both the decline in a long-standing industry and growth in the public sector, which made these structural changes important for the greater developments in the area. Moreover, the response rate declined throughout the four HUNT surveys, stabilising at 54% of the invited population in HUNT4. The lower response rate might have increased the risk of sampling bias. However, a nonparticipant study following HUNT3 revealed no significant differences in poor self-rated health between participants and nonparticipants (Langhammer et al., 2012). Relatedly, groups with weaker ties to the community may have been difficult to recruit for participation in research. Although the rural coastal area in this study has a lower portion of migrant workers compared with other fish-farming municipalities in Central Norway (IMDi, 2021), varying experiences of integration into the area (Rye, 2018) may have resulted in lower participation in this group. In addition, selective migration is an unknown factor when studying geographical disparities in health. Because selective migrants have been found to exhibit better health (Riva et al., 2011), outmigration from rural coastal areas should not be dismissed as a potential factor in interpreting findings.

Third, our findings may not be fully generalised to other rural coastal areas that have been affected by the international decline in small-scale fishing. The characteristics of Norwegian rural coastal areas, such as high welfare expenditures, advanced fishing technology and new employment opportunities in the public sector and aquaculture, may have contributed into the trend of narrowing educational inequalities in health. Therefore, one cannot automatically expect narrowing social inequalities in rural coastal communities that have not experienced the same societal restructuring. Findings from the UK indicated lower rates of employment in coastal areas and that coastal employment tended to involve low-skilled and seasonal labour (Depledge et al., 2017). Additionally, concerns have been raised that many potential growth sectors in marine technology are not based in coastal areas (Morrissey, 2017). Such conditions may result in increased vulnerability of rural coastal inhabitants with less formal education compared with this Norwegian setting, and they should be considered in cross-national comparisons. Nonetheless, the findings of the present study are relevant to both coastal and non-coastal areas that have experienced the restructuring of local industries, especially those industries with a history of employing inhabitants with low educational attainment.

Finally, it should be noted that we did not have access to health data in the decades preceding and during the initial drops in fish stocks starting in the late 1950s (Christensen, 2014). Considering the vulnerability of the fishing workforce to stock changes, there may have been an increase in educational inequalities in health during the early declines, which were not captured in the data of this study. Nevertheless, the timespan of the HUNT Study has allowed for tracking health levels during substantial industrial restructuring, including milestones such as the cod crisis in the 1980s, the introduction of quota regulations and the emergence of fish farming, which provide valuable insights into the developments of educational inequalities in self-rated health following an industry decline and the transition to new employment opportunities.

5. Conclusion

The shift in the rural coastal labour market, as a natural experiment at the population level, has entailed both a transition from large-scale employment in small-scale fishing to bigger and safer fishing vessels and parallel growth in employment opportunities in the public sector and aquaculture. The findings of this study showed that rural coastal areas exhibited the largest prevalence of poor self-rated health compared with other geographical regions across four decades. Nevertheless, relative educational inequalities in self-rated health decreased in the rural coastal areas. There is reason to believe that earlier, there were greater differences in both working conditions and employment vulnerability between educational levels, as people in the dominant primary sector of small-scale fishing, who had little formal schooling, were exposed to both hazardous working conditions and unemployment following stock crises. Our findings contrast to national and European overall trends of increasing or stable relative educational inequalities in self-assessed health. In this study population, absolute educational inequalities in self-rated health increased in all geographical areas, where rural coastal areas exhibited the smallest increase. Compared with other geographical areas, the rural coastal areas exhibited more stability in the prevalence of poor self-rated health in participants with primary education and a slight increase in the prevalence of poor self-rated health in participants with tertiary education. Hopefully, as existing literature on regional differences in inequalities in self-rated health is limited, our findings encourage comparisons to be made among smaller areas to explore regional differences in educational inequalities in health in future studies. Our findings also indicated that the mechanisms underpinning health in rural coastal areas may differ from those in other rural areas. Therefore, further studies on the health of coastal areas should be conducted. Furthermore, we recommend exploring trends using a wide range of health measurements, including both lifestyle habits and specific diseases, to attain nuanced knowledge on educational inequalities in health in societies that undergo restructuring.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2021.114541.

Credit author statement

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Supplementary material: Trends in absolute and relative social inequalities in health during times of industrial restructuring in coastal areas. The HUNT Study, Norway.

Table 1: 1960 municipality characteristics of (former) Nord-Trøndelag County, Norway

Municipality	Km^2 land per km coastline	Inhabitants	Employed (total)	Employed in fishing (main occupation)	Percentage of total employment in fishing
Rural coast					
Fosnes	2.53	974	327	40	12.2
Flatanger	0.56	1703	630	148	23.5
Vikna	0.13	3880	1458	398	27.3
Nærøy	0.85	6604	2380	232	9.7
Leka	0.25	1105	404	75	18.6
Urban (coast)					
Steinkjer	16.55	18922	6920	10	<1
Namsos	1.51	10775	4162	57	1.4
Stjørdal	19.43	12917	4711	2	<1
Levanger	3.79	12922	4753	25	<1
Verdal	82.19	9087	3307	6	<1
Rural inland					
Meråker	-	3352	1177	0	0
Snåsa	-	3244	1126	0	0
Lierne	-	2018	746	0	0
Røyrvik	-	461	188	0	0
Namsskogan	-	1693	595	0	0
Grong	-	3107	1055	1	<1
Høylandet	35.14	1546	519	3	<1
Overhalla	344.22	3511	1193	0	0
Rural fjord					
Frosta	1.14	2940	961	38	4
Leksvik*	8.16	2913	1087	8	<1
Mosvik*	2.98	1241	435	9	2
Verran*	7.86	4589	1577	11	<1
Namdalseid	7.82	2156	732	26	3.6
Inderøy	1.32	4982	1706	14	4

*New municipal affiliations in parentheses: Leksvik (Indre Fosen, 2017), Mosvik (Inderøy, 2012) and Verran (parted between Steinkjer and Indre Fosen, 2020)

Table 2: Age-standardised prevalence of poor self-rated health and absolute (Slope index of inequality, SII) and relative (Relative index of inequality, RII) educational inequalities (95% CI in brackets) in poor self-rated health in men.

	HUNT1 (1984-86)	HUNT2 (1995-97)	HUNT3 (2006-08)	HUNT4 (2017-19)	Change HUNT1-HUNT4	P for trend
Rural coast						
Primary	40.5	41.5	40.9	36.2		
Secondary	24.9	28.2	26.1	27.0		
Tertiary	21.7	23.5	23.5	22.7		
SII	20.08 (12.79-27.38)	25.17 (17.66-32.69)	21.71 (12.72-30.70)	13.83 (6.11-21.56)	-31.1%	**<0.001**
RII	2.70 (1.95-3.72)	2.60 (2.00-3.37)	2.37 (1.76-3.18)	1.65 (1.25-2.18)	-38.9%	**0.002**
Urban (coast)						
Primary	29.2	33.2	34.7	32.7		
Secondary	21.7	24.3	22.0	22.9		
Tertiary	13.1	17.2	16.3	15.4		
SII	15.13 (12.53-17.73)	21.21 (18.63-23.80)	17.86 (14.79-20.93)	18.65 (16.10-21.20)	+23.3%	**<0.001**
RII	2.46 (2.17-2.79)	2.48 (2.22-2.77)	2.39 (2.07-2.74)	2.41 (2.12-2.74)	-2%	0.081
Rural inland						
Primary	27.5	29.7	28.1	27.4		
Secondary	17.9	25.0	23.6	21.0		
Tertiary	13.5	16.0	16.3	15.9		
SII	12.34 (6.91-17.77)	16.14 (9.90-22.39)	21.10 (14.25-27.96)	12.59 (6.85-18.33)	+2%	0.781
RII	2.51 (1.86-3.39)	1.98 (1.57-2.50)	2.33 (1.78-3.05)	1.76 (1.34-2.32)	-29.9%	**0.211**
Rural fjord						
Primary	34.2	34.4	37.3	34.4		
Secondary	25.6	29.1	27.7	23.1		
Tertiary	19.8	18.1	21.0	15.7		
SII	15.58 (9.55-21.61)	20.79 (14.53-27.04)	19.21 (12.18-26.24)	18.23 (12.41-24.05)	+17%	**0.007**
RII	2.26 (1.77-2.89)	2.10 (1.72-2.57)	1.92 (1.51-2.45)	2.38 (1.83-3.10)	+5.3%	0.457

*P-values of interaction term

Values in bold indicate p-values <0.05

Table 3: Age-standardised prevalence of poor self-rated health and absolute (Slope index of inequality, SII) and relative (Relative index of inequality, RII) educational inequalities (95% CI in brackets) in poor self-rated health in women.

	HUNT1 (1984-86)	**HUNT2 (1995-97)**	**HUNT3 (2006-08)**	**HUNT4 (2017-19)**	**Change HUNT1-HUNT4**	**P for trend**
Rural coast						
Primary	42.6	44.6	45.1	50.7		
Secondary	27.3	36.6	36.8	36.1		
Tertiary	21.5	28.0	28.8	24.1		
SII	17.96 (9.62-26.30)	27.24 (19.16-35.32)	27.88 (19.12-36.63)	32.79 (25.23-40.35)	+82.6%	0.204
RII	2.60 (1.79-3.79)	2.25 (1.77-2.87)	2.05 (1.60-2.63)	2.56 (2.03-3.24)	-1.5%	0.068
Urban (coast)						
Primary	32.3	36.3	38.0	44.5		
Secondary	25.2	29.9	30.1	29.8		
Tertiary	21.5	23.5	21.3	20.8		
SII	13.02 (10.35-15.70)	17.66 (15.02-20.29)	21.38 (18.36-24.40)	23.51 (20.95-26.07)	+80.6%	**0.015**
RII	2.13 (1.86-2.45)	1.93 (1.75-2.14)	2.00 (1.80-2.24)	2.37 (2.14-2.63)	+11.3%	**<0.001**
Rural inland						
Primary	29.7	35.0	45.2	37.3		
Secondary	20.0	28.5	29.3	30.9		
Tertiary	15.4	19.2	23.8	21.0		
SII	11.44 (5.60-17.27)	20.07 (13.88-26.26)	19.28 (12.64-25.92)	23.42 (12.10-29.73)	+104.7%	0.631
RII	2.37 (1.70-3.31)	2.27 (1.78-2.89)	1.83 (1.43-2.34)	2.09 (1.68-2.62)	-11.8%	**0.006**
Rural fjord						
Primary	35.3	39.0	45.3	45.6		
Secondary	24.9	34.6	30.4	33.8		
Tertiary	18.8	24.7	21.7	19.6		
SII	10.17 (4.11-16.22)	18.34 (12.05-24.63)	25.55 (18.88-32.21)	30.66 (24.65-36.67)	+201.5%	0.943
RII	2.16 (1.63-2.87)	1.87 (1.53-2.28)	2.16 (1.73-2.70)	2.67 (2.16-3.31)	+23.6%	0.184

*P-values of interaction term

Values in bold indicate p-values <0.05

Appendix

Appendix 1: List of municipalities and their classification

Appendix 2: Links to questionnaires used in this dissertation

Appendix 1: List of municipalities and their classification

Due to municipality mergers between HUNT3 and HUNT4, the classification of rural fjord municipalities in HUNT4 differs slightly from the classification in HUNT1-HUNT3.

Table 1: *The classification of municipalities in HUNT1-HUNT3*

Rural coast	**Urban coast**	**Rural inland**	**Rural fjord**
Fosnes	Steinkjer	Meråker	Frosta
Flatanger	Namsos	Snåsa	Leksvik
Vikna	Stjørdal	Lierne	Mosvik
Nærøy	Levanger	Røyrvik	Verran
Leka	Verdal	Namsskogan	Namdalseid
		Grong	Inderøy
		Høylandet	
		Overhalla	

Table 2*: The classification of municipalities in HUNT4*

Rural coast	**Urban coast**	**Rural inland**	**Rural fjord**
Fosnes	Steinkjer	Meråker	Frosta
Flatanger	Namsos	Snåsa	Verran
Vikna	Stjørdal	Lierne	Namdalseid
Nærøy	Levanger	Røyrvik	Inderøy[1]
Leka	Verdal	Namsskogan	Indre Fosen[2]
		Grong	
		Høylandet	
		Overhalla	

[1] *Mosvik municipality was included in Inderøy municipality in 2012.*

[2] *Leksvik municipality was merged with Rissa municipality (former Sør-Trøndelag county) in 2018, which now comprise the municipality of Indre Fosen.*

Appendix 2: Links to questionnaires used in this dissertation

HUNT1

Questionnaire 1

Norwegian original:

https://www.ntnu.no/c/document_library/get_file?uuid=3cef0dc4-832b-4a14-93ad-ebe3fe91aa83&groupId=10304

English translation:

https://www.ntnu.edu/c/document_library/get_file?uuid=e85b678b-94fe-4bf3-ae09-1e9cac1d18b7&groupId=140075

Questionnaire 2

Norwegian original:

https://www.ntnu.no/documents/10304/1268411139/NT1BLQ2_1984-01-01.pdf/5e8f32a5-d7dd-4998-ba2f-a972e10ba0ec

English translation:

http://www.ntnu.edu/c/document_library/get_file?uuid=a173dabd-d59e-4be1-ad40-fcd1b915fe11&groupId=140075

HUNT2

Questionnaire 1

Norwegian original:

https://www.ntnu.no/c/document_library/get_file?uuid=c6786f4d-6175-459c-a80a-5d4268cc166e&groupId=10304

English translation:

http://www.ntnu.edu/c/document_library/get_file?uuid=262e55e8-f8df-43c2-8ad0-d26b762d830c&groupId=140075

HUNT3

Questionnaire 1

Norwegian original:

https://www.ntnu.no/c/document_library/get_file?uuid=65b9ce4f-c712-4cdd-a1b1-ff67a6df42c8&groupId=10304

English translation:

http://www.ntnu.edu/c/document_library/get_file?uuid=129b68c3-520c-457f-8b98-02c49219b2ee&groupId=140075

Questionnaire 2

Norwegian originals:

Women in the age group 20-29 years:

https://www.ntnu.no/c/document_library/get_file?uuid=59251eca-90df-4eb8-86d4-06db64717349&groupId=10304

Men in the age group 20-29 years:

https://www.ntnu.no/c/document_library/get_file?uuid=3f2e4452-b5c1-4c8d-8a33-81b28d864dd2&groupId=10304

Women in the age group 30-69 years:

https://www.ntnu.no/c/document_library/get_file?uuid=2145c89c-e3c9-4537-aff4-40dacf16301c&groupId=10304

Men in the age group 30-69 years:

https://www.ntnu.no/c/document_library/get_file?uuid=cc8e74d5-4164-4b6e-971a-4c4138540411&groupId=10304

Women ≥ 70 years:

https://www.ntnu.no/c/document_library/get_file?uuid=c5d79d2d-066e-47ed-a1d4-c4e582e64385&groupId=10304

Men ≥ 70 years:

https://www.ntnu.no/c/document_library/get_file?uuid=a28a1c33-1957-4655-abf4-a3562df65fa2&groupId=10304

English translation (also including all age-specific questionnaires):

http://www.ntnu.edu/c/document_library/get_file?uuid=35ae2816-4155-4b64-a259-770946fa46d4&groupId=140075

Field station interview guide:

Norwegian original:

http://www.ntnu.no/c/document_library/get_file?uuid=29f055ef-9adb-440c-ab45-28c1eb46b66d&groupId=10304

English translation: Not available

HUNT4

Questionnaire 1

Norwegian original:

https://www.ntnu.no/documents/10304/901151116/HUNT4_Q1.pdf/edaa10d7-faa7-4899-8b28-f714adf13d30

English translation: Not available

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