Contents lists available at ScienceDirect

SSM - Population Health

Increasing health inequality among Inuit in Greenland from 1993 to 2018: Different patterns for household assets, urbanization and a sociocultural index as indicators of social position

Peter Bjerregaard [a,*], Durita Lyngsø Svartá [a], Charlotte Brandstrup Ottendahl [a], Christina Viskum Lytken Larsen [a,b]

[a] *Centre for Public Health in Greenland, National Institute of Public Health, University of Southern Denmark, Studiestræde 6, 1455 Copenhagen K, Denmark*
[b] *Institute of Health and Nature, University of Greenland, Manutooq 1, 3905 Nuussuaq, Greenland*

ARTICLE INFO

ABSTRACT

Income inequality affects population health and wellbeing negatively. In Greenland, health inequality has been shown to exist among social groups, regionally and according to urbanization, and between Inuit and migrants from Denmark. The purpose of the study was to compare the changes in health inequality from 1993 to 2018 according to three measures of social position, i.e. a socioeconomic measure (household assets), a measure of urbanization and a composite sociocultural index. We hypothesized that social inequality in health increased parallel to the increasing economic inequality in Greenland. The sample was based on four population health surveys conducted among the Inuit in Greenland in 1993, 2005–2010, 2014 and 2018. The total number of interviews was 9024 and the total number of individuals interviewed was 5829, as participants were invited to several surveys as part of a cohort. As statistical measure of social disparity we used the slope index of inequality (SII) adjusted for age and sex. Analyses were performed with daily smoking, suicidal thoughts and obesity as health outcomes. Daily smoking was most prevalent among participants with low social position whereas obesity was most prevalent among participants with high social position. With household assets as indicator of social position, the results showed high and increasing social inequality for both daily smoking and obesity. Social inequality for daily smoking increased over time also for urbanization and the sociocultural index. The hypothesis that social inequality increased over time was thus confirmed for daily smoking and obesity but not for suicidal thoughts. With the results from the present study there is solid evidence to guide prevention and health care towards social equality in health.

1. Introduction

The prevailing evidence underscores the profound impact of income inequality on population health and well-being, with a growing body of research affirming its detrimental influence on health and its social repercussions (Pickett & Wilkinson, 2015). While addressing health risk behaviors among individuals with lower education and income can enhance overall population health, studies indicate that this alone may not suffice to reduce inequality (Lantz et al., 1998). The ongoing debate regarding the influence of absolute versus relative income inequality on health outcomes raises complexities, and discerning the interplay between these mechanisms remains challenging (Diez-Roux, Link, & Northridge, 2000; Kawachi, Subramanian, & Almeida-Filho, 2002). In

the context of Greenland, we suggest that health inequalities stem from absolute poverty in remote regions characterized by suboptimal housing and employment conditions, particularly when contrasted with more centrally located communities. Additionally, we argue that relative socioeconomic inequalities within communities and between Greenland and wealthier Western countries have a significant negative impact on mental well-being.

The persistence of socioeconomic health inequalities, even in nations boasting economic prosperity and human development, remain a challenge within the field of public health (Mackenbach, 2012). Within the eight member states of the Arctic Council, marked social inequality in health has been demonstrated between Indigenous peoples of the circumpolar North and the affluent majority populations of the south

(Young, Broderstad, Sumarokov, & Bjerregaard, 2020), but studies within Indigenous populations are sparse.

1.1. Greenland

Greenland is the world's largest island but only a narrow coastal strip is inhabited. The Inuit migrated to Greenland from what is now northern Canada around 1100-1300 AD and today form a majority in the country at 92% (Young & Bjerregaard, 2019). The total population numbered 56,000 in 2018. Greenland was a Danish colony until 1953 and is now a self-governing part of the Kingdom of Denmark. Greenland has undergone major societal changes from the beginning of the 20th century, when living conditions changed drastically and a rapid modernization of the society began (Bjerregaard & Larsen, 2018). These social changes occurred simultaneously with an epidemiological transition, where infectious diseases as the most frequent causes of death until the 1950s were replaced by chronic diseases, cancers and suicide (Bjerregaard & Larsen, 2018). At present, the social differences in education, employment and living conditions among residents of towns and villages and of different regions are substantial (Bjerregaard et al., 2018; Ottendahl et al., 2021). Health inequality has been shown to exist among social groups, regionally and according to urbanization, and between Inuit and migrants from Denmark (Bjerregaard & Bjerregaard, 1985; Bjerregaard & Dahl-Petersen, 2011; Bjerregaard & Larsen, 2015; Jørgensen, Borch-Johnsen, Witte, & Bjerregaard, 2012). The Government of Greenland has for several years focused on reducing social inequalities in health through public health strategies. The first public health strategy (Inuuneritta I) was issued in 2007. It stated that social issues were essential for public health (Homerule of Greenland, 2007). Later, social inequality in health was an overarching theme in the public health strategy Inuuneritta II 2013–2019 (Government of Greenland, 2012), and in the current public health strategy Inuuneritta III 2020–2030 (Government of Greenland, 2020) social inequality in health is listed as an indicator to monitor public health in Greenland. Present day social inequality among the Inuit in Greenland should be viewed in an historical context and in particular in relation to the post-colonial development since 1953.

1.2. Social inequality in the colonial and post-colonial period

Epidemiological researchers have investigated social inequalities in health in Greenland during the past 100 years. In the early 1900s, Bertelsen reported differences in social position measured by housing conditions and the proportion of children having proper clothes (Bertelsen, 1937). In the post-colonial period, studies using income as a social indicator found that mortality from acute respiratory infections decreased with increasing income (Bjerregaard, 1990). From 1951 to 1989, infant mortality showed great regional variation and was significantly higher in villages than in towns (Bjerregaard & Misfeldt, 1992). The countrywide population health surveys in Greenland have since 1993 provided data for several studies concerning social inequality in health. Height increased with increased social position (measured by education) (Bjerregaard, 2010), diabetes decreased with urbanization (Jørgensen et al., 2012), but contrary to the tendency in western populations, obesity increased with increasing social position (Bjerregaard & Jørgensen, 2013). Other studies have found social differences in dietary patterns and expenditure on alcohol and tobacco (Bjerregaard & Jeppesen, 2010; Bjerregaard & Larsen, 2021). A report based on data among youth in the most recent population health survey showed social inequalities in e.g. satisfaction with life and mental illness in favour of youth in a higher social position (estimated by household assets) (Ottendahl et al., 2021). The possible changes in social inequality over time have not been studied before.

The assessment of social position among Inuit in Greenland was examined by (Bjerregaard et al., 2018). In their study, different indicators of social position among Inuit in Greenland were compared as

part of a continued discussion about the usefulness of traditional western socioeconomic indicators among Indigenous populations. The authors concluded that traditional socioeconomic indicators that are used extensively in research in western countries (education, income and employment) were useful among the Inuit too. Two sociocultural indicators developed for use among the Inuit, which included parameters specific to the transition to an urban lifestyle, proved to be equally useful as the western socioeconomic indicators but they did not add to the explanatory power of simple socioeconomic variables. The study further concluded that the choice of social indicator depends on the research setting and the use of more than one indicator was recommended (Bjerregaard et al., 2018).

1.3. Purpose of the study

The purpose of the study is to compare the changes in health inequality among the Inuit in Greenland between 1993 and 2018 employing three measures of social position: a socioeconomic measure (household assets), a measure of urbanization and a composite sociocultural index. Analyses were performed for three measures of health - daily smoking, ever having had suicidal thoughts and obesity. Our hypothesis suggests a parallel rise in social inequality in health alongside increasing economic inequality in Greenland, quantified by the Gini coefficient.

2. Material and methods

2.1. Population health surveys in Greenland

As part of Greenland's public health strategy, the results from the recurrent health surveys have been used to study the epidemiology of social and behavioural risk factors. Four countrywide health interview surveys from 1993 to 2018 provided the data for the present study. The surveys recruited adult (age 18+) residents of Greenland randomly selected from the whole country. Through interviewer administered questionnaires, the surveys collected data about physical and mental health, diabetes, obesity, diet, physical activity, alcohol, smoking, sociocultural conditions and childhood. Interviews were carried out in the language of choice by the participants, most often Kalaallissut. In most of the surveys, questionnaire information was supplemented by clinical examinations and blood sampling. The present study only included participants who identified themselves as Inuit (93% of all survey participants). Inuit identity was determined by asking about self-perceived identity (Would you call yourself Greenlandic or Danish?) with the categories "Greenlandic/Inuit", "Danish", "Both Greenlandic and Danish", "Don't know" and "Other". Among the 286 participants (3.2%) who answered "Both Greenlandic and Danish" or "Don't know", 138 were subsequently categorized as Greenlanders/Inuit if they spoke Kalaallissut fluently and had Greenlandic ancestors.

The four surveys were conducted in 1993–1994 in 38 communities (acronym: B1993; n = 1513 Inuit; 57% participation) (Bjerregaard & Young, 1998); in 2005–2010 in 22 communities (acronym IHIT; n = 3059 Inuit; 67% participation) (Bjerregaard, 2011); in 2014 in 19 communities (acronym B2014; n = 2096 Inuit; 63% participation) (Dahl-Petersen, Olesen, Jørgensen, Larsen, & Bjerregaard, 2016); and in 2016–2019 in 20 communities (acronym B2018; n = 2356 Inuit; 52% participation) (Bjerregaard et al., 2022). Fig. 1 shows the communities in Greenland where the four studies were carried out. The total number of interviews was 9024 and the total number of individuals interviewed was 5829. In total, 3423 individuals participated in one survey, 1634 in two and 772 in more than two surveys. The B2014 and B2018 surveys were designed as follow-up studies of the IHIT survey and accordingly 1834 individuals participated in both the IHIT survey and one or both of the later surveys. Overall participation rate was 60% but varied according to age and sex. In all surveys, women had a higher participation rate than men and persons above middle age participated more often
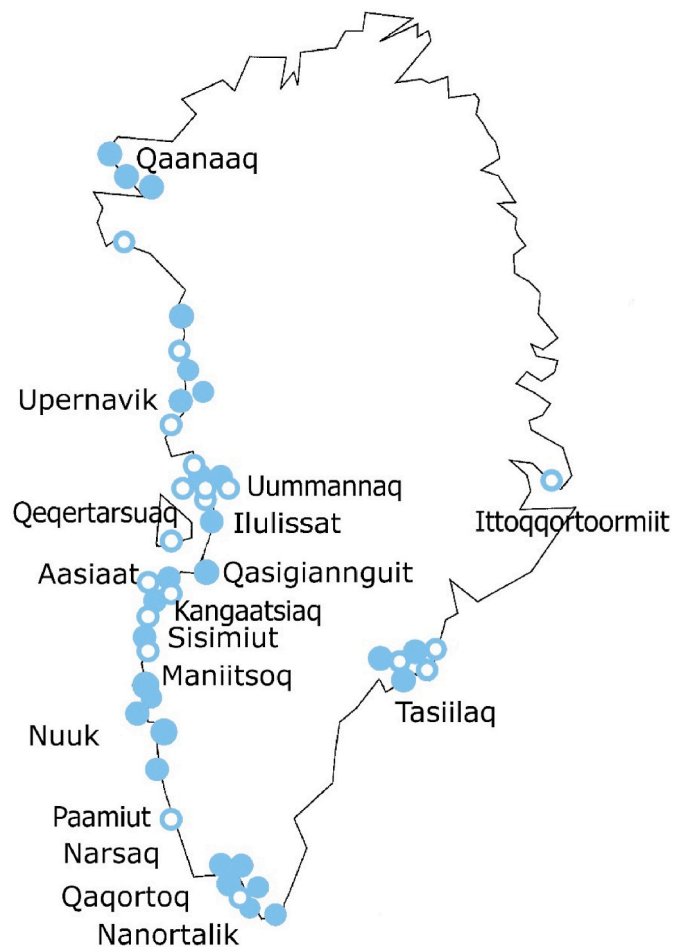
Fig. 1. Study communities in four population health surveys with the names of larger communities (towns). Open circles are communities that were only surveyed in 1993-1994 (B1993).

that young people. The authors have been involved in these surveys since 1993 and have extensive research experience from Greenland in social medicine, public health and sociology.

2.2. Measures of social position

Social inequality was analysed for three social variables: Household assets, urbanization and a sociocultural index. Household asset score is calculated from household ownership of a number of durable household goods. In a dynamic society with increasing wealth it is necessary to continuously revise the list of assets. In B1993, the score was based on ownership of TV, video player, telephone, refrigerator and microwave oven, in IHIT (2005–2010) and B2014 washing machine and dishwashing machine were added, whereas in B2018 telephone and refrigerator were removed and internet access was added. In B2018, the household asset score was thus based on ownership of video/DVD player, computer, microwave oven, washing machine, dishwashing machine and internet. The 0/1 answers were added, yielding a household asset score ranging from 0 to 5/7 depending on the survey. The household asset score is an indicator of social position that is closely associated with more traditional measures of socioeconomic position, such as education and income, but it has certain practical advantages and is often used in a Greenlandic context (Bjerregaard et al., 2018; Bjerregaard & Larsen, 2018). Information was available for 99.9% of participants.

Urbanization was recorded as current residence in the capital, larger communities (population ≥3000), medium sized communities (population 600–2999) and smaller communities (villages) or the remote North or East Greenland. Information was available for 99.8% of participants.

An index of sociocultural position was calculated from education, residence 10 years old, current residence and proficiency in the two major languages in Greenland (Kalaallissut and Danish). No education beyond primary or secondary school, childhood and residence in a village, and lack of proficiency in one of the major languages were each assigned the value of 0; short education, childhood and residence in a town and fluency in one language and some knowledge of the other were assigned the value of 1, whereas medium-long or long education, childhood and residence in the capital, and fluency in both major languages were assigned the value of 2. Because education was part of the index it was defined for participants aged 25+ only since higher education is not expected to finish before this age. A score ranging from 0 to 8 was calculated as the sum of the four variables. Information was available for 97.4% of participants aged 25+ years. The index was developed for a study of traditional diet in Greenland (Bjerregaard et al., 2017) and was validated against other socioeconomic and sociocultural measures (Bjerregaard et al., 2018).

2.3. Health outcomes

From a limited number of health outcomes available in all four surveys, three were chosen because they were of greatest importance for public health: daily smoking which decreased over time, ever having had serious suicidal thoughts which remained almost unchanged and obesity which increased.

Daily smoking was determined from a single question "Do you smoke" with the reply categories "Yes, daily", "Yes, but there are days when I don't smoke" and "No". Information was available for 99.6% of participants.

Suicidal thoughts were assessed by the question "Have you ever thought seriously about committing suicide?" with answers "Yes" and "No". This question was posed in a self-administered questionnaire that some respondents chose not to complete. Information was thus only available from 7326 interviews (81.2%).

Obesity was defined as body mass index ≥30 kg/m^2 (BMI). In B1993 height and weight were self-reported; in the other surveys both were measured with the participants wearing underwear only. Height was measured to the nearest millimetre and weight to the nearest 100 g. Self-reported BMI was available for 10.7% of participants and measured BMI was available for 80.9% of participants, in total 91.6%.

2.4. Statistics

As indicator of social inequality, we used the slope index of inequality (SII) (Harper & Lynch, 2007). SII is the regression of a health variable against the ranked social position. In our case we have expressed the health variable as good health = 0 and poor health = 1 and have inversed the ranked social position with high social position = 0 and low social position = 1. A positive SII thus indicates a higher proportion of poor health among participants with low social position. SII was calculated in the standard statistical package SPSS v. 28.0 as the unstandardized coefficient B (β in standard nomenclature) in a linear regression model adjusted for age and sex and with ranked social position as determinant. SII for individual survey years in Fig. 2 were compared using the summary T-test of SPSS v. 28.0 and statistics for the comparison of B1993 and B2018 were presented. Age in years truncated was calculated by subtracting the date of birth (obtained from the civil registration number) from the date of interview. Sex was defined from the last digit of the civil registration number where even numbers indicate female sex and odd numbers male sex. Cases with missing values were treated as missing only for the specific models where values were missing. As a sensitivity analysis, we conducted the analyses in Table 2 for primary interviews only.
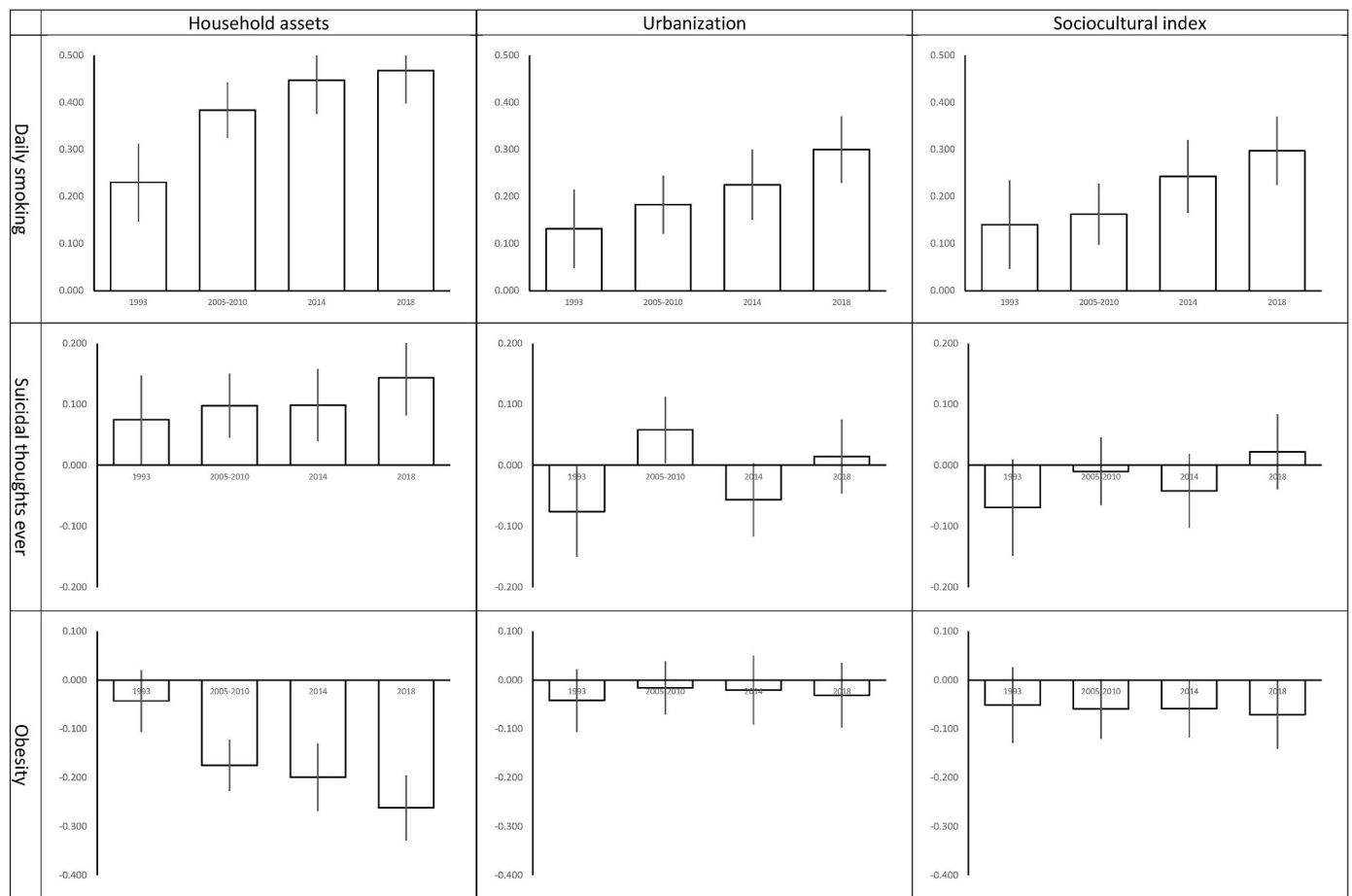
Fig. 2. Social inequality in daily smoking, suicidal thoughts ever and obesity with household assets, urbanization and sociocultural index as measures of social position. Comparison of surveys in Greenland in 1993, 2005–2010, 2014 and 2018.

3. Results

3.1. Survey characteristics

Table 1 shows that median age, distribution on sex, prevalence of health indicators and prevalence of social conditions varied among the surveys. Due to differences in survey design and population sample, the age of the participants and the social variables, in particular urbanization, differed among the surveys. In B1993 and IHIT, almost all interviews were obtained from participants who had not been interviewed before (primary interviews) whereas in B2014 and B2018 more than half of the interviews were with participants who had been interviewed

Table 1
Population characteristics in four health surveys in Greenland 1993–2018.

	Survey				
	B1993	IHIT	B2014	B2018	p
N	1513	3059	2096	2356	
n for suicidal thoughts	1227	2472	1745	1882	
Non-primary interviews	0	102	1575	1518	<0.001
Age (median)	36	44	50	50	<0.001
Sex (% female)	53.6	55.8	61.2	55.6	<0.001
Adjusted for age and sex					
Family assets (mean)	3.0	4.2	4.8	4.0	<0.001
Urbanization (% living in the capital)	14.8	14.1	26.6	17.4	<0.001
Sociocultural index (mean)	2.8	2.9	3.6	3.4	<0.001
Daily smoking (%)	68.9	61.7	59.2	57.1	<0.001
Suicidal thoughts ever (%)	13.2	17.3	17.2	18.7	<0.001
Obesity (BMI 30+ %)	11.4	23.4	28.0	28.4	<0.001

before (non-primary interviews). The mean score of household assets also fluctuated because the algorithm for this variable differed among surveys. The proportion of daily smokers decreased whereas obesity and suicidal thoughts increased.

3.2. Inequality in health

Fig. 2 compares social inequality in health in four surveys in Greenland from 1993 to 2018.

For daily smoking the disparity statistics were positive which means that the prevalence of smoking decreased by increasing social position. The time trend was similar for all three measures of social position, namely a visibly increasing and statistically significant trend in inequality by survey year (p < 0.001 for household assets; p = 0.003 for urbanization and p = 0.01 for the sociocultural index). The disparity statistics for suicidal thoughts were positive or negative, and the temporal trend was not statistically significant for any of the measures of social position. For obesity the disparity statistics were negative which means that participants with high social position more often were obese. With household assets as the social measure there was a distinctly increasing temporal trend in inequality (p=<0.001) whereas there was no temporal trend for urbanization and sociocultural index.

3.3. Comparison of three measures of social position

Table 2 shows that in statistical models adjusted for age and sex, household assets were significantly associated with all three measures of health. Urbanization was associated with smoking only and sociocultural index with smoking and obesity. The three measures of social

Table 2

Association of health disparities (β = Slope Index of Inequality) with three indicators of social position. Adjusted for age, sex and the other measures of social position in linear regression models. Health surveys in Greenland 1993–2018. N = 9024; n in analyses = 6333–8976.

	Daily smoking n = 8987		Suicidal thoughts ever n = 7326		Obesity (BMI 30+) n = 8264	
	β	p	β	p	β	p
Models adjusted for age and sex						
Household assets (n = 9014)	0.40	<0.001	0.10	<0.001	−0.19	<0.001
Urbanization (n = 9004)	0.21	<0.001	−0.001	0.97	−0.02	0.36
Sociocultural index (n = 7857)	0.22	<0.001	−0.02	0.24	−0.06	0.002
Models adjusted for age, sex and the other measures of social position						
Household assets (n = 9014)	0.40	<0.001	0.13	<0.001	−0.21	<0.001
Urbanization (n = 9004)	0.09	<0.001	0.002	0.94	0.06	0.02
Sociocultural index (n = 7857)	0.002	0.95	−0.07	0.002	−0.009	0.73

position were associated and in models adjusted for age, sex and the two other measures of social position the results were slightly different. Household assets were still associated with all three measures of health and the SIIs were similar to those of the more simple model described above. Urbanization was still associated with smoking but now also with obesity. The SSI for smoking was smaller than in the simpler model. Sociocultural index was now associated with suicidal thoughts and not with smoking and obesity as before.

Among our observations, 5829 were primary interviews and 3195 were second, third, or even fourth interviews of the same participant. In these non-primary interviews age was naturally higher and there were more women than in the primary interviews and the two types of interview also differed with respect to both social and health variables: participants in the non-primary interviews were wealthier, more urbanized and scored higher on the sociocultural scale; there were fewer daily smokers, and there were more obese participants (p < 0.001 for all variables). Many but not all differences were influenced by the older age at the subsequent interviews. The distribution of primary and non-primary interviews differed among the surveys and is a possible source of bias. We therefore performed a sensitivity analysis with separate analyses of primary interviews. Although there were differences, the overall conclusions were identical (Supplement Table 1).

4. Discussion

With household assets as indicator of social position, our results showed high and increasing social inequality for daily smoking and obesity. The hypothesis that social inequality increased over time was thus confirmed for daily smoking and obesity but not for suicidal thoughts. Two other measures of social position showed less clear results.

4.1. Measures of social position

In order to throw light on social inequality from different perspectives we chose to analyse health inequality in relation to an economic measure (household assets), a measure of urbanization and a composite measure that included education, place of residence and language (the sociocultural index). Although the indicators were statistically associated, they were not identical and emphasized different aspects of social position. Other possible indicators of social position available in the data were education which had the disadvantage that it had few categories

and was skewed towards the left (55% of the participants had no education beyond primary school), and job category which was also unevenly distributed and only defined for participants between 25 and 66 years of age which is the usual working age. The choice of indicators of social position was further constrained by the fact that they must be available for and identical in all four surveys.

The use of different measures of social position showed that results and conclusions regarding social inequality in health are sensitive to the social indicator chosen and thus emphasizes the importance of using more than one indicator of social position. In this study, a socioeconomic indicator (household assets) showed clear and statistically significantly increasing trends in social inequality for smoking and obesity and no trend for suicidal thoughts whereas the trends for urbanization and the sociocultural index were statistically significant for smoking but absent for suicidal thoughts and obesity. Household assets which is a traditional socioeconomic indicator thus provided the most clear answer to our research question and was also stronger associated with the health outcomes than the other two measures of social position. Urbanization is a proxy measure of individual social position and it is not surprising that it is less associated with health than individual household assets since there is considerable social variation within urbanization strata. The sociocultural index is an attempt at creating an alternative to the traditional socioeconomic measures. We have over the years worked on the development of indicators that are culture sensitive and specific for the Inuit in Greenland (Bjerregaard et al., 2018). This work is far from finished but the current sociocultural index is considered to be one step forward. Future work on the index will include factor analyses of the four items that are part of the index (childhood residence, current residence, education and language) and comparisons of health inequality for a range of health issues with both the sociocultural index and a socioeconomic measure as determinants. For the time being a socioeconomic measure tailored to conform with local circumstances (household assets) still seems to be the best choice of indicator among the three indicators used in the study.

4.2. Measures of health

Smoking, suicidal thoughts and obesity were chosen as indicators of health because they represent important public health challenges, were available in all four surveys and showed different time trends: increasing, almost constant and decreasing population prevalence, respectively. With household assets as measure of social position the three health outcomes followed three different epidemiological patterns, i.e. increasing prevalence and increasing inequality for smoking, constant prevalence and unchanged inequality for suicidal thoughts and decreasing prevalence and increasing inequality for obesity. There was no case of decreasing social inequality in the available data. These patterns clearly show that the magnitude and direction of social inequality differs according to the health outcome studied and the measure of social position chosen. For daily smoking there was a temporal decrease in prevalence and increasing social inequality. A likely explanation is that this is due to a decreasing prevalence among the wealthiest and stagnation among the least wealthy, a pattern which is also known, for instance, from screening programmes where higher social groups participate more often (Dickson et al., 2023; Schütte, Dietrich, Montet, & Flahault, 2018). For obesity, the overall increasing prevalence was most likely due to an increasing prevalence in all social groups but more pronounced among the wealthiest. Detailed analyses may elucidate these mechanisms, but this was considered beyond the scope of the present paper. Other measures of health may of course have given other results regarding social inequality (Harper & Lynch, 2007), but our results constitute the first steps in a discussion of social inequality in health in Greenland.

For all three health outcomes we chose dichotomized statistics (daily smoking vs. not daily or not at all; yes or no to suicidal thoughts, and body mass index 30+ vs. <30 kg/m^2) and we did not consider it within

the scope of the present paper to explore how different treatment of health outcome variables influenced the outcome (social inequality). For smoking we chose daily smokers vs. occasional and non-smokers whereas other outcomes such as ever vs. never smokers, heavy smokers vs. other or number of pack-years were not considered and might have yielded different conclusions regarding inequality. For obesity, other cut-points or a summary measure (body mass index) might yield different results.

4.3. Managing social inequality in health

Despite political focus on reducing economic inequality and social inequality in health (Government of Greenland, 2020, 2021) our results showed increasing social inequality in health during the period studied. The public health strategies have thus not reached their goals; this is not specific to Greenland but is a universal phenomenon (Mackenbach, 2012). Mackenbach further points out that there is good evidence that welfare policies have contributed to a reduction of inequalities in income, housing quality, health care access and other social and economic outcomes, but they have apparently been insufficient to eliminate health inequalities.

Social inequality is created by unequal distribution of education, wealth and access to resources (World Health Organization, 2008). In Greenland, several measures of economic inequality including the Gini-coefficient have increased since 2002. The Gini-coefficient was highest in 2017 (36.0) compared to 34.0 in 2002 (Greenland Statistics, 2022) whereas there was no information from earlier periods. No explanation has been offered for this but it must be seen as part of the transition from an egalitarian economy based on subsistence hunting and fishing to a modern western society with a mixed economy. This general trend in socioeconomic inequality may be part of the explanation for increasing inequality in health.

It is one of the roles of the Greenlandic health care system to alleviate the health consequences of social inequality by offering free and equal health care to all citizens irrespective of where they live (Sullissivik, 2023). Clinical health care has probably little effect on the health outcomes studied in the present paper, whereas preventive measures such as information about the consequences of smoking, publicly available smoking cessation initiatives, increased tax on tobacco, ban on smoking in public places, information about healthy eating and the benefits of physical exercise, increased access to healthy food and not the least the prevention of adverse experiences during childhood such as the Greenlandic "Early efforts" programme (Olesen, Hansen, & Larsen, 2022) are likely to have had an impact over the past decades (Andersen, Schou et al., 2022; Ingemann, Beck, & Larsen, 2019). However, the results of the present study highlight the existence of social inequality in health among the Inuit and show that some of these inequalities have increased over the last 25 years even for health outcomes that have improved. This study has provided evidence to guide the way towards equality in health by documenting and identifying how different social groups among Inuit in Greenland are positioned differently regarding their health status across different measures. The results can thus be used to guide more precise and targeted interventions to reduce the inequality between these groups. Our results show how persons of low social position tended to become increasingly unhealthy over time compared with their fellow citizens of high social position. Preventive strategies should therefore focus more on population groups with low social position. Prevention and public health programs often suffer from a 'one size fits all' perspective. With these analyses we have demonstrated the population diversity and the higher needs of certain population groups. We argue that due to these inequalities different approaches are necessary for different population subgroups to increase equity. Furthermore, we as researchers work closely with the health authorities and the municipalities to translate these results into action, with the purpose of transforming the presented evidence into targeted interventions in collaboration with not only the health sector but across sectors, including both the educational and social sectors. These interventions in return must be evidence-based and culturally relevant to the Greenlandic context.

4.4. Generalizability to other indigenous peoples

The present study is one of very few studies of social inequality within an Indigenous population and to our knowledge the only one that has followed inequalities over time. In contrast to the strong associations between socioeconomic position and health in Greenland, there was a less universal and less consistent pattern in Indigenous Australian health although education and health were inextricably linked among young Indigenous Australians (Johnston, Lea, & Carapetis, 2009; Shepherd, Li, & Zubrick, 2012). Compared with other Indigenous peoples, data on social position and health from the Inuit in Greenland are detailed and plentiful and although each Indigenous people is unique the findings from Greenland are relevant for the Inuit in Greenland, Canada and Alaska and for other Indigenous peoples in the Arctic for whom large disparities have been shown in relation to the southern majority populations (Young et al., 2020).

4.5. Strengths and limitations

A major strength of the study is the large dataset which included as many as 12% of the total adult Inuit population in Greenland during the period of study, an excellent representation of the many diverse communities in the country and a study period of 25 years with four studies of similar design and comparable variables. Another strength is the use of three indicators for social position which illustrates the multifaceted nature of social inequality. Furthermore, the continued adjustment of the definition of the household asset score to changing social conditions enhances comparability of this variable over time. Since we used ranked measures of social position, changes in the size of population subgroups are not a critical issue from a statistical point of view.

Height and weight were self-reported in the B1993 survey and measured in the subsequent surveys, but a small validation study showed good accordance between self-reported and measured height and weight (Bjerregaard, Mulvad, & Pedersen, 1997). We analysed 9024 observations among 5829 individual and as such apparently violated the assumption of independence among observations. We argue that since each individual only participated once in each survey, observations were nevertheless independent when analyses were stratified by survey. The choice of measures of health outcomes and social position was constrained by what was available in all four surveys thus excluding recent work on social position among the Inuit that incorporated culturally relevant measures.

4.6. Conclusion

With a socioeconomic measure as indicator of social position, daily smoking and obesity exhibited increasing social inequality among the Inuit in Greenland between 1993 and 2018. With the results from the present study the evidence is now available to guide targeted prevention strategies and health care towards increased social equality in health between different socioeconomic groups. In the absence of local data, the results from Greenland can be useful for other indigenous communities that struggle with inequality in health, particularly in the circumpolar North but also worldwide.

Funding

Ethical statement

Ethical approval of the study was obtained from Greenlandic Ethics Committee (KVUG 5.113/76; 505-95; 2012–07642; 2017–5582) and written informed consent was obtained from all participants.

CRediT authorship contribution statement

Peter Bjerregaard: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Durita Lyngsø Svartá:** Formal analysis, Writing – original draft, Writing – review & editing. **Charlotte Brandstrup Ottendahl:** Formal analysis, Writing – original draft, Writing – review & editing. **Christina Viskum Lytken Larsen:** Conceptualization, Investigation, Supervision, Writing – review & editing.

Declaration of competing interest

The authors report there are no competing interests to declare.

Data availability

The authors do not have permission to share data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2024.101635.

References

Andersen, C. M., Schou, M., & Niclasen, B. (2022). *Årsrapport 2021 [Annual report 2021. In Danish]*. Nuuk: Allorfik, The national addiction treatment service. Retrieved from https://allorfik.gl/-/media/allorfik/pdf-filer/allorfiks-udgivelser/rapporter/dk-aarsrapport-2021.pdf?la=da&hash=5FD3AE844AAFC0544B578672D396EE2E.

Bertelsen, A. (1937). *Grønlandsk medicinsk Statistik og Nosografi. II. Grønlands Befolkningsstatistik 1901-30 [Greenland medical history and nosography. I. Population statistics of Greenland 1901-30. In Danish]. Meddr Grønland 117/2*.

Bjerregaard, P. (1990). Geographic variation of mortality in Greenland. Economic and demographic correlations. *Arctic Medical Research, 49*(1), 16–24.

Bjerregaard, P. (2010). Childhood conditions and education as determinants of adult height and obesity among Greenland Inuit. *American Journal of Human Biology, 22*(3), 360–366. https://doi.org/10.1002/ajhb.20999

Bjerregaard, P. (2011). *Inuit Health in Transition – Greenland survey 2005-2010. Population sample and survey methods*. Copenhagen: National Institute of Public Health, University of Southern Denmark. Retrieved from https://www.sdu.dk/sif/-/media/images/sif/sidste_chance/sif/udgivelser/2010/inuit_health_in_transition_greenland_methods_5_002.pdf. (Accessed 27 February 2023).

Bjerregaard, P., & Bjerregaard, B. (1985). *Disease pattern in Upernavik in relation to housing conditions and social group* (Vol. 8). Meddr Grønland, Man & Society.

Bjerregaard, P., & Dahl-Petersen, I. K. (2011). How well does social variation mirror secular change in prevalence of cardiovascular risk factors in a country in transition? *American Journal of Human Biology, 23*(6), 774–779. https://doi.org/10.1002/ajhb.21209

Bjerregaard, P., Dahl-Petersen, I. K., & Larsen, C. V. L. (2018). Measuring social inequality in health amongst indigenous peoples in the Arctic. A comparison of different indicators of social disparity among the Inuit in Greenland. *SSM Popul Health, 6*, 149–157. https://doi.org/10.1016/j.ssmph.2018.08.010

Bjerregaard, P., & Jeppesen, C. (2010). Inuit dietary patterns in modern Greenland. *International Journal of Circumpolar Health, 69*(1), 13–24. https://doi.org/10.3402/ijch.v69i1.17387

Bjerregaard, P., & Jørgensen, M. E. (2013). Prevalence of obesity among Inuit in Greenland and temporal trend by social position. *American Journal of Human Biology, 25*(3), 335–340. https://doi.org/10.1002/ajhb.22372

Bjerregaard, P., & Larsen, C. V. L. (2015). Time trend by region of suicides and suicidal thoughts among Greenland Inuit. *International Journal of Circumpolar Health, 74*(1). https://doi.org/10.3402/ijch.v74.26053

Bjerregaard, P., & Larsen, C. V. L. (2018). Three lifestyle-related issues of major significance for public health among the Inuit in contemporary Greenland: A review of adverse childhood conditions, obesity, and smoking in a period of social transition. *Public Health Reviews, 39*(1). https://doi.org/10.1186/s40985-018-0085-8

Bjerregaard, P., & Larsen, C. V. L. (2021). Social determinants of dietary patterns, food basket costs and expenditure on alcohol and tobacco amongst Greenland Inuit. *Public Health Nutrition, 24*(15), 4975–4984. https://doi.org/10.1017/s1368980020005133

Bjerregaard, P., Larsen, C. V. L., Dahl-Petersen, I. K., & Buchardt, B. (2017). Stable isotopes of carbon and nitrogen as markers of dietary variation among sociocultural subgroups of Inuit in Greenland. *American Journal of Human Biology, 29*(5). https://doi.org/10.1002/ajhb.23018

Bjerregaard, P., Larsen, C. V. L., Olesen, I., Ottendahl, C. B., Backer, V., Senftleber, N., … Jørgensen, M. E. (2022). The Greenland population health survey 2018 – methods of a prospective study of risk factors for lifestyle related diseases and social determinants of health amongst Inuit. *International Journal of Circumpolar Health, 81*(1). https://doi.org/10.1080/22423982.2022.2090067

Bjerregaard, P., & Misfeldt, J. (1992). Infant mortality in Greenland: Secular trend and regional variation. *Arctic Medical Research, 51*(3), 126–135.

Bjerregaard, P., Mulvad, G., & Pedersen, H. (1997). Cardiovascular risk factors in Inuit of Greenland. *International Journal of Epidemiology, 26*, 1182–1190.

Bjerregaard, P., & Young, T. (1998). *The circumpolar Inuit: Health of a population in transition*. Copenhagen: Munksgaard.

Dahl-Petersen, I. K., Olesen, I., Jørgensen, M. E., Larsen, C. V. L., & Bjerregaard, P. (2016). *Health survey in Greenland 2014: Population sample and survey methods*. Copenhagen: National Institute of Public Health, University of Southern Denmark. Retrieved from https://findresearcher.sdu.dk/ws/portalfiles/portal/123980490/greenlandsurvey2014_methods_final_til_web_2_.pdf. (Accessed 27 February 2023).

Dickson, J. L., … Hall, H., Horst, C., Tisi, S., Verghese, P., Mullin, A.-M., … Janes, S. M. (2023). Uptake of invitations to a lung health check offering low-dose CT lung cancer screening among an ethnically and socioeconomically diverse population at risk of lung cancer in the UK (SUMMIT): A prospective, longitudinal cohort study. *The Lancet Public Health, 8*(2), e130–e140. https://doi.org/10.1016/s2468-2667(22)00258-4

Diez-Roux, A. V., Link, B. G., & Northridge, M. E. (2000). A multilevel analysis of income inequality and cardiovascular disease risk factors. *Social Science & Medicine, 50*(5), 673–687. https://doi.org/10.1016/s0277-9536(99)00320-2

Government of Greenland. (2012). *Inuuneritta II. Naalakkersuisuts strategi og målsætning for folkesundheden 2013-2019 [The Government's strategy on public health 2013-2019. In Danish]*. Retrieved from https://paarisa.gl/-/media/paarisa/materialer/film-og-udgivelser/rapporter/inuunerittaii_dk_small.pdf?la=da&hash=D714BB967B1E58469A037EBB1FDFE519.

Government of Greenland. (2020). *Inuuneritta III. Naalakkersuisuts strategi for samarbejdet om det gode børneliv 2020-2030 [The Government's strategy on a healthy childhood. In Danish]*. Retrieved from https://paarisa.gl/-/media/paarisa/materialer/film-og-udgivelser/rapporter/inuuneritta-iii-sep20-naal-da-web_final.pdf?la=da&hash=AB47485216A652E52B89327CD6A2C3CC.

Government of Greenland. (2021). *Koalitionsaftale - solidaritet, stabilitet, vækst [coalition agreement - solidarity, stability and growth. In Danish]*. Retrieved from https://ia.gl/wp-content/uploads/2021/04/koalitionsaftale_DA.pdf.

Greenland Statistics. (2022). *Indkomststatistik [income statistics, in Danish]*. Retrieved from https://stat.gl/publ/da/IN/202201/pdf/2021%20Indkomststatistik.pdf (Accessed 27 February 2023).

Harper, S., & Lynch, J. (2007). Trends in socioeconomic inequalities in adult health behaviors among U.S. States, 1990–2004. *Public Health Reports, 122*(2), 177–189. https://doi.org/10.1177/003335490712200207

Homerule of Greenland. (2007). *Inuuneritta – folkesundhedsprogram. Landsstyrets strategier og målsætninger for folkesundheden 2007 – 2012 [The Homerule's strategy on public health 2007-2012. In Danish]*. Retrieved from https://paarisa.gl/-/media/paarisa/materialer/film-og-udgivelser/rapporter/inuuneritta_dk_final_web_2007.pdf?la=da&hash=0B7B194E7B33C6F87DA8924EF6871ACE.

Ingemann, C., Beck, A., & Larsen, C. (2019). *Kortlægning af rygestoptilbud: Undersøgelse af borgernes adgang til rygestop i kommuner og sundhedsvæsenet i grønland [mapping of smoking cessation services: A study of access to smoking cessation inmunicipalities and the healthcare system in Greenland. Danish]*. Copenhagen: National Institute of Public Health, University of Southern Denmark. Retrieved from https://www.sdu.dk/sif/-/media/images/sif/sidste_chance/sif/udgivelser/2019/kortlaegning_af_rygestoptilbud.pdf.

Johnston, V., Lea, T., & Carapetis, J. (2009). Joining the dots: The links between education and health and implications for Indigenous children. *Journal of Paediatrics and Child Health, 45*(12), 692–697. https://doi.org/10.1111/j.1440-1754.2009.01596.x

Jørgensen, M. E., Borch-Johnsen, K., Witte, D. R., & Bjerregaard, P. (2012). Diabetes in Greenland and its relationship with urbanization. *Diabetic Medicine, 29*(6), 755–760. https://doi.org/10.1111/j.1464-5491.2011.03527.x

Kawachi, I., Subramanian, S. V., & Almeida-Filho, N. (2002). A glossary for health inequalities. *Journal of Epidemiology & Community Health, 56*(9), 647–652. https://doi.org/10.1136/jech.56.9.647

Lantz, P. M., House, J. S., Lepkowski, J. M., Williams, D. R., Mero, R. P., & Chen, J. (1998). Socioeconomic factors, health behaviors, and mortality: Results from a nationally representative prospective study of US adults. *JAMA, 279*(21), 1703–1708. https://doi.org/10.1001/jama.279.21.1703

Mackenbach, J. P. (2012). The persistence of health inequalities in modern welfare states: The explanation of a paradox. *Social Science & Medicine, 75*(4), 761–769. https://doi.org/10.1016/j.socscimed.2012.02.031

Olesen, I., Hansen, N. L., & Larsen, C. V. L. (2022). *Evaluering af "Tidlig Indsats overfor gravide familier" [Evaluation of "Early efforts to protect pregnant families. In Danish]*. Copenhagen: National Institute of Public Health, University of Southern Denmark. Retrieved from https://www.sdu.dk/sif/-/media/images/sif/udgivelser/2022/tidlig_indsats.pdf.

Ottendahl, C. B., Bjerregaard, P., Svartá, D. L., Sørensen, I. K., Olesen, I., Nielsen, M. S., & Larsen, C. V. L. (2021). *Mental sundhed og helbred blandt 15-34 årige i Grønland. Betydningen af opvækstvilkår, beskyttende faktorer og risikofaktorer [Mental health among youth in Greenland. In Danish]*. Copenhagen: National Institute of Public Health, University of Southern Denmark. Retrieved from https://www.sdu.dk/sif/-/media/images/sif/udgivelser/2021/mental_sundhed_unge_helbred_dk.pdf.

Pickett, K. E., & Wilkinson, R. G. (2015). Income inequality and health: A causal review. *Social Science & Medicine, 128*, 316–326. https://doi.org/10.1016/j.socscimed.2014.12.031

Schütte, S., Dietrich, D., Montet, X., & Flahault, A. (2018). Participation in lung cancer screening programs: Are there gender and social differences? A systematic review. *Public Health Reviews, 39*(1). https://doi.org/10.1186/s40985-018-0100-0

Shepherd, C. C. J., Li, J., & Zubrick, S. R. (2012). Social gradients in the health of indigenous Australians. *American Journal of Public Health, 102*(1), 107–117. https://doi.org/10.2105/ajph.2011.300354

Sullissivik. (2023). *Sundhedsvæsenets ydelser [Provision of health care. In Danish]*. Retrieved from https://www.sullissivik.gl/Emner/Sundhed_og_sygdom/Sundheds vesnets_ydelser/Sundhedsvaesenets-ydelser_nyt-design?sc_lang=da-DK. (Accessed 31 March 2023).

Young, T. K., & Bjerregaard, P. (2019). Towards estimating the indigenous population in circumpolar regions. *International Journal of Circumpolar Health, 78*(1). https://doi.org/10.1080/22423982.2019.1653749

Young, T. K., Broderstad, A. R., Sumarokov, Y. A., & Bjerregaard, P. (2020). Disparities amidst plenty: A health portrait of indigenous peoples in circumpolar regions. *International Journal of Circumpolar Health, 79*(1). https://doi.org/10.1080/22423982.2020.1805254