

RESEARCH ARTICLE

Inequalities in health outcomes by income and education: The case of Norway

Carl Michael Baravelli¹ , Tord Finne Vedøy¹ , Rannveig K. Hart^{1,2} ,
Jonas Minet Kinge^{1,2}  and Astri Syse¹ 

ABSTRACT Reducing social inequalities in health is a priority in European policy and the UN's Sustainable Development Goals. We aim to estimate the magnitude of health inequalities in Norway, a high-income country with a universal health care system but rising income inequality. Using survey and registry data, we estimated relative and absolute inequality in self-reported health, health behaviours and mortality by education and income, using the Relative and Slope Index of Inequality (RII/SII). Social disparities in health were evident across nearly all outcomes, for both income and education and for both sexes. Significant RIIs were found for self-reported health, long-standing health problems, global activity limitations, dental health and the behavioural risk factors of smoking, obesity, physical inactivity, low fruit (women only) and vegetable intake, and various causes of deaths. Inequality by income were particularly pronounced for mortality among men, with the RII for men's all-cause mortality reaching 6.2 (CI 5.9–6.5) for income, compared to 3.6 (3.5–3.8) for education. SIIs were also significant for all outcomes, except for fruit intake for education among men. Thus, despite its extensive welfare system, income- and education-related health inequalities persist in Norway, highlighting the need for targeted policy interventions. Proportionate universalism may be a valuable strategy to address these disparities within European efforts to improve public health.

KEYWORDS Education • Health • Income • Mortality • Registry • Survey • Inequality

Introduction

Motivation

Marked socio-economic inequalities in health persist across Europe and reducing them is a key priority for most European countries (European Commission, 2021; Joint Action Prevent Non-Communicable Diseases Project, 2024), including Norway (Meld. St. 15 (2022–2023)). Addressing these disparities is also central to the United Nations' Sustainable

✉ Astri Syse, Astri.Syse@fhi.no

The two first authors hold a joint first authorship.

1 Norwegian Institute of Public Health, Oslo, Norway

2 Department of Health Management and Health Economics, University of Oslo, Oslo, Norway

Development Goals (SDGs), particularly Goal 3 (Good Health and Well-being) and Goal 10 (Reduced Inequalities) (Morton et al., 2017; United Nations, 2015).

Using Norway as a case, we examine how education and household income are associated with behavioural risk factors and health outcomes (mortality) among working-age adults, leveraging both survey data (2015 and 2019) and full population register data (2015–2019).

Norway ranks among the top countries in the Human Development Index (United Nations Development Programme, 2024), and has low income inequality, a generous social security system (Barth et al., 2021; Eurostat, 2023; Molven and Ferkis, 2011) and one of the highest per capita health expenditures in Europe (WHO Regional Office for Europe, 2025). Norway has made reducing socio-economic health inequalities a political priority. A government white paper from 2007 called for targeted efforts to reduce inequalities over the next decade, particularly in smoking, nutrition and physical activity (St.meld. nr. 20 (2006–2007)). Despite this, significant socio-economic inequalities in mortality and health-related behaviours persist (Mackenbach, 2017, 2019; Mackenbach et al., 2008).

Given Norway's focus on reducing social inequalities in health and its fast rate of adoption of international health regulations (World Health Organisation, 2025), examining the state of social inequalities in health in Norway can illustrate the regulatory challenges other European countries face in reducing inequalities.

Poor health disproportionately affects lower socio-economic groups, increasing health-care demand, sickness absences and reliance on social security. Given the strong relationship between education, income and health outcomes, reducing inequality in these social determinants may help to mitigate health disparities. Improving healthcare services and optimising treatment outcomes, which are often worsened by behavioural risk factors, are also critical. These measures, alongside broader policies grounded in proportionate universalism, are necessary to effectively reduce health inequalities.

This study contributes to existing knowledge in three key ways. First, it employs established methods of measuring inequality (Relative Index of Inequality, RII, and Slope Index of Inequality, SII) (Mackenbach et al., 2008; Mackenbach et al., 2018) across multiple behavioural risk factors and mortality indicators, facilitating cross-country comparability. Second, it combines survey and registry data to assess whether inequalities are consistent across different data sources, and to what degree inequalities are associated with specific measures. Third, it provides up-to-date estimates of absolute and relative health inequalities in a country with a strong welfare system and a longstanding political commitment to reducing disparities. Given the rising income inequality and shifting educational demographics in Norway (Statistics Norway, 2021), understanding how inequalities emerge across different health measures remains crucial. We address the following research questions:

- To what extent do socio-economic inequalities in health exist among adults in Norway?
- How do inequalities differ by education and income?
- Are these differences consistent across various health outcomes and gender?
- Do survey and registry data yield comparable findings?

Empirical background

In 2019, Norway had a higher life expectancy (83 vs 81 years) and lower rates of all-cause mortality¹ (701 vs 770), daily smoking (9% vs 17%), BMI of 25 or more (48% vs 56%), self-reported less-than-good health² (37% vs 55%) and activity limitations² (23% vs 50%) compared to other OCED countries. Levels of daily vegetable consumption (58% vs 59%) and insufficient daily physical activity (34% vs 35%) were similar to the OECD average (OECD, 2021).

Recent studies show that marked and relatively persistent differences in lifestyle, health, use of health services and mortality exist in Norway (Goldblatt et al., 2023; Gutacker et al., 2023; Kinge et al., 2015, 2023) as well as in other European countries (Enroth and Fors, 2021; Gallo et al., 2012; Mackenbach et al., 2015a; Moor et al., 2017), and that these differences are related to both education and income.

However, the magnitude of the estimates depends on which health outcomes are investigated and whether relative or absolute differences are examined, and also partly on the context (who, where and when) (Granström et al., 2015; Hu et al., 2016; Lahelma et al., 2019; Leão et al., 2018; van der Wel et al., 2018).

Since the publication of the British Black report and the Whitehall I study (Marmot et al., 1978; Townsend and Davidson, 1982), an extensive literature has documented health inequalities, particularly in self-reported health and mortality, from the early 1990s onwards (see, for instance, Hu et al., 2016; Kunst et al., 2005; Lahelma and Arber, 1994; Lahelma et al., 1997, 2002; Mackenbach et al., 1997; Strand et al., 2010; von dem Knesebeck et al., 2006; Yngwe et al., 2001).

In general, health inequalities have remained stable even during economic crises, including during the 2008 financial crisis (Leão et al., 2018; Mackenbach et al., 2018). Leão et al. attributed this stability to countries avoiding austerity policies (Leão et al., 2018). Mackenbach et al. (2018), however, observed a slowdown in the decline in less-than-good health among people with both short and long education, even in the hardest hit countries.

Most studies on health inequalities focus on education, though some also include individual or household income. Although the mechanisms linking income, education and health are complex, income can be regarded as a measure of material resources, while education represents ability, information and social and cultural capital (Dahl, 1994; Goldman, 2001). Research consistently shows that people with higher education or higher income report better health and live longer lives than their less advantaged counterparts.

However, few existing studies on health inequalities, with notable exceptions (Huijts et al., 2010; Lahelma et al., 2004; Muller, 2002), have examined the impact of both education and income. Even fewer studies have examined results from both relative and absolute perspectives across a wider range of health outcomes using both population survey and full-population samples. By including a wide range of risk factors and measures of mortality and assessing inequality in terms of both education and income, we aim to provide a

1 Age-standardised rates per 100,000 population.

2 Among people aged 65 and older.

comprehensive picture of socio-economic inequality in Norway using the latest available data from before the COVID-19 epidemic.

Data and methods

Data

We used two data sources: representative surveys and registries. The sample included adults aged 30–69 years, as most of this group had completed their education and established an income, while excluding most retirees.

Survey data

We used self-reported health and health behaviour data from *Survey on Living Conditions* 2015 and 2019 (Statistics Norway, 2016, 2020). The Survey on Living Conditions is a nationally representative, cross-sectional survey that is conducted every 3–4 years and is harmonised with the *European Health Interview Survey* (EHIS).³ Pooled data from 10,382 participants were linked to national registry data on education and income by Statistics Norway before an anonymised release for research. The response rates were 59% (2015) and 57% (2019) (Statistics Norway, 2016, 2020). Ethical approval (2023/1333) for our study was granted by the Norwegian Agency for Shared Services in Education and Research.

We analysed nine measures: obesity, the Minimal European Health Module⁴ ([MEHM], comprising self-reported general health, longstanding health problems and the Global Activity Limitation Indicator [GALI]), self-reported dental health and four health behaviours (smoking, fruit and vegetable intake and exercise). These measures were selected because they are used in comparative studies or align with WHO's healthy diet recommendations (World Health Organisation, 2020). Dental health was included because it is generally not covered by social security for most adults in Norway.

Registry data

For the mortality analyses, we used comprehensive registry data covering the entire population from Statistics Norway (2015–2019, N=2.64 million)⁵ and cause-specific data from the Cause of Death Registry. Data were linked at the individual level. The Regional Ethics Committee (2013/2394) approved the data linkage and analysis, and a de-identified file was provided to researchers.

3 See <https://ec.europa.eu/eurostat/web/microdata/european-health-interview-survey>.

4 For questions and response alternatives, see [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Minimum_European_Health_Module_\(MEHM\)](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Minimum_European_Health_Module_(MEHM)).

5 We limited the latest year to 2019 for two reasons: (i) we wanted the period covered to be as similar as possible in the survey and registry data; and (ii) we did not want to include the pandemic years to avoid confounding the results.

Categories included causes amenable to medical intervention, such as infectious diseases, cervical and breast cancer, Hodgkin's disease leukaemia, hypertension, cerebrovascular disease, pneumonia/influenza, appendicitis/hernia/gastric ulcer, cholecystitis and lithiasis and maternal mortality. Smoking-related causes were specified as bronchitis, chronic obstructive pulmonary disease (COPD), bronchiectasis and cancers of the mouth, pharynx, oesophagus, trachea, bronchi and lungs.

Categorisation of outcome variables

Self-reported health was dichotomised as not good ("fair", "bad" or "very bad") vs good ("good" or "very good").⁶ Having a longstanding illness or health problem was categorised as "yes" vs "no". For activity limitations, we combined "severely limited" and "not severely limited" (vs "not limited"). Self-reported dental health followed the same categorisation as self-reported health. Other self-reported measures were obesity (BMI > 30), current smoking (daily or non-daily), physical inactivity (exercise < 1 day per week) and low fruit and vegetable intake (≤ 1 /day for both).

All-cause mortality was defined as death irrespective of the cause. Cause-specific mortality categories were based on the International Classification of Diseases, 10th edition (ICD-10) codes from the Cause of Death Registry, following previously applied categorisations (Mackenbach et al., 2008). These included causes amenable to medical intervention (i.e., diseases that can be effectively treated or managed with timely and appropriate medical management), which were comprised of infectious diseases (A00-B99), cervical cancer (C53), breast cancer (C50), Hodgkin's disease and leukaemia (C81, C91-C95), hypertension (I10-I15), cerebrovascular disease (I60-I69), pneumonia/influenza (J10-J18), appendicitis, hernia and gastric ulcer (K25-K28, K35-K38, K40-K46, K56), cholecystitis and lithiasis (K80-K83) and maternal mortality (O00-O99). Smoking-related causes included bronchitis (J40), COPD (J41-J44), bronchiectasis (J47), cancer of the mouth, pharynx and oesophagus (C00-C15) and cancer of the trachea, bronchi and lungs (C33-C34, C39).

Categorisation of demographic and socio-economic variables

We categorised age into four age groups: 30–39, 40–49, 50–59 and 60–69 years. Men and women were analysed separately. Education and income data from registers were categorised into three groups: *low*, *medium* and *high*. Educational attainment followed the International Standard Classification of Education (ISCED 2011): low (ISCED 0–2, secondary school or shorter), medium (ISCED 3 and 5, secondary and vocational school) and high (ISCED 6–8, higher education).⁷ Income was based on household income after tax, adjusting for household size using the square root scale (OECD, 2013). To account for potential unreported income among individuals with extremely low or negative reported income, we set a lower inclusion limit at 200,000 NOK (~17,600 euros at time of writing).

6 For questions and response alternatives, see [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Minimum_European_Health_Module_\(MEHM\)](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Minimum_European_Health_Module_(MEHM)).

7 See <https://www.ssb.no/klass/klassifikasjoner/139>.

This excluded <2% of the survey respondents and 3.4% of the registry data, including individuals with missing information. For educational attainment, we further excluded individuals with missing information, and in total this applied to 2.2% of the survey respondents and 3.5% of the registry data.⁸ The Goodman and Kruskal's gamma value for the association between education and income was 0.31 in the survey data and 0.43 in the register data, indicating a moderate association. Table 1 summarises the numbers of men and women analysed for each health outcome.

Methods

To investigate the associations between health behaviours, outcomes and socio-economic position (educational and income), we employed two gender-specific regression-based inequality indices (cf. Mackenbach et al., 2008) to pooled 2015 and 2019 data: (1) the Relative Index of Inequality (RII) for relative differences and (2) the Slope Index of Inequality (SII) for absolute differences.

Both the RII and the SII are regression-based measures that account for the distribution of socio-economic characteristics in the samples (Mackenbach and Kunst, 1997; Mackenbach et al., 2008). To estimate the RII and the SII, we calculated “ridits” for education and income using the “wridit” command (Newson, 2012) in Stata 18 (StataCorp LLC, 2023), stratified by gender and five-year birth cohort. Ridits represent cumulative probabilities on a continuous scale, ranging from zero (lowest status) to one (highest status) (Donaldson, 1998). Specifically, the ridit for value x of variable X is the proportion of values lower than x , plus half of the proportion of values equal to x . For example, the middle income tertile has a mean ridit value of 0.5 ($0.33 + [0.33/2]$).

The RII was calculated by regressing the ridit-transformed education and income variables on the outcomes (mortality, MEHM and self-reported dental health, obesity, smoking and fruit/vegetable intake) using generalised linear regression models (GLM) with Poisson-family and log-link. RII was the exponentiated beta coefficient.

The SII, representing the absolute difference between the lowest and the highest education and income groups, was similarly calculated using GLM with an identity-link. SII was the beta coefficient of the transformed education and income variables. Hjorthen et al. (2022) demonstrated that these calculation methods yield results equivalent to Mackenbach et al. (2008).

Regression models for self-reported health and health behaviours were adjusted for 10-year age groups and a dummy variable for calendar year. Survey weights, accounting for age, sex, education and geographical region of residence, were applied to ensure representativeness when examining self-reported health and health behaviours.

⁸ In Table 1, the income from the living conditions surveys is consumer price index (CPI) adjusted to 2015. In other figures and tables, the income percentiles are specific to each year.

Table 1 An overview of percentages and mean values for different health behaviours and outcomes by education and income

		Data from surveys								Data from registers					
		Full survey sample	Less than good health	Global Activity Limitation Indicator	Long-standing health problems	Less than good dental health	Smoke currently	BMI >30 (obesity)	Low physical activity (<1day/week)	Low fruit intake (≤1/day)	Low vegetable intake (≤1/day)	Full register population	All-cause mortality	Medical intervention-amenable mortality ^a	Smoking-related mortality ^b
Men															
<i>N with specific outcome</i>		5140 5119 ^d	1042	817	1784	1286	1101	888	1589	2820	2681	1.29 mill.	29,957	2266	4638
<i>Percentages</i>															
<i>Income</i>															
Lowest income tertile		33.54	27.96	22.30	37.69	32.44	27.42	18.19	37.63	56.54	54.82	33.33	3.11	0.26	0.49
Middle income tertile		33.17	17.90	14.61	35.17	22.63	18.96	17.85	29.69	54.29	50.73	33.33	1.44	0.10	0.22
Highest income tertile		33.29	13.10	9.36	29.11	17.95	15.51	15.37	23.64	50.41	48.16	33.33	0.93	0.06	0.13
<i>Education</i>															
Basic education		16.23	30.93	25.69	40.72	34.50	35.97	21.16	42.28	60.61	58.95	20.32	3.58	0.27	0.63
Secondary education		47.26	21.05	16.67	35.25	24.60	21.85	18.45	33.11	55.38	52.88	46.67	2.27	0.17	0.36
Tertiary education		36.51	13.92	9.90	30.09	20.14	12.53	13.55	20.72	49.76	46.36	33.02	1.23	0.09	0.14
<i>Mean (standard deviation)</i>															
Age		49.99 (11.28)	53.02 (10.84)	52.91 (10.58)	52.43 (10.94)	50.22 (11.14)	50.18 (11.14)	50.40 (10.89)	48.78 (11.21)	48.85 (10.99)	49.67 (11.02)	48.18 (11.22)	58.97 (9.16)	60.93 (7.97)	60.84 (7.10)
Income ^c		469,607 (192,756)	418,789 (184,691)	410,292 (178,194)	453,698 (195,408)	425,192 (175,403)	452,527 (180,884)	452,748 (172,773)	432,095 (170,980)	459,199 (183,409)	456,573 (180,559)	547,024 (706,427)	426,176 (439,158)	391,684 (240,845)	408,350 (368,740)
Women															
<i>N with specific outcome</i>		5069 5030 ^d	1105	1126	2151	1010	1068	704	1133	1875	1692	1.24 mill.	19,639	3239	3040
<i>Percentages</i>															
<i>Income</i>															
Lowest income tertile		33.46	30.72	28.47	47.28	26.63	26.65	17.10	30.47	41.57	37.93	33.33	1.99	0.29	0.30
Middle income tertile		33.44	20.53	21.66	42.01	18.13	20.15	14.28	35.84	33.04	33.04	33.33	1.02	0.18	0.17
Highest income tertile		33.10	13.42	15.44	36.43	13.60	15.66	10.88	15.48	32.10	27.73	33.33	0.70	0.13	0.10
<i>Education</i>															
Basic education		14.43	41.05	37.62	55.31	31.77	36.14	19.46	32.97	45.58	40.88	19.77	2.69	0.39	0.47
Secondary education		35.25	24.82	24.90	44.55	18.93	23.52	16.31	21.14	35.88	35.99	38.54	1.71	0.28	0.28
Tertiary education		50.32	13.95	15.82	36.90	16.63	14.77	11.08	18.99	34.52	28.96	41.69	0.72	0.14	0.07
<i>Mean (standard deviation)</i>															
Age		49.62 (11.17)	51.99 (10.50)	51.05 (10.57)	51.34 (10.88)	50.53 (11.45)	50.69 (10.78)	50.11 (10.63)	48.46 (11.25)	48.57 (10.88)	49.03 (11.00)	48.48 (11.30)	59.46 (8.77)	58.43 (9.09)	61.15 (6.78)
Income ^c		451,000 (190,386)	387,551 (156,083)	400,597 (160,005)	429,189 (180,517)	395,968 (156,348)	410,608 (169,495)	413,296 (159,038)	402,452 (176,591)	429,373 (180,671)	426,358 (177,572)	528,003 (579,003)	396,449 (327,169)	429,263 (383,697)	385,562 (284,170)

^a Medical intervention-related mortality include causes of death where medical interventions are available, i.e., infectious diseases (A00-A99), cervical cancer (C53), breast cancer (C50), Hodgkin's disease and leukemia (C81, C91-C95), hypertension (I10-I15), cerebrovascular disease (I60-I69), pneumonia and influenza (J10-J18), appendicitis, hernia and peptic ulcer (K25-K28, K35-K38, K40-K46, K56), cholecystitis and lithiasis (K80-K83) and maternal deaths (O00-O99).

^b Smoking-related mortality include deaths caused by bronchitis (J40), COPD (J41-J44), bronchiectasis (J47), cancer of the oral cavity, pharynx and oesophagus (C00-C15) and cancer of the trachea, bronchi and lungs (C33-C34, C39).

^c The income from the 2019 living conditions survey is consumer price index (CPI) adjusted to 2015 values. The currency is Norwegian kroner (NOK), 1,000 NOK=88 Euros (May 2024). In the sample survey, there were minimal differences in the numbers included for education and income, respectively. In the register analyses, the discrepancy was greater, and the figures for income were 23,507, 1,708 and 3,642 for men and 15,353, 2,532 and 2,362 for women. The incomes are somewhat higher in the register data compared to the sample surveys, since the very richest contribute to raising the average considerably. The median values are NOK 483,001 (IQ=362,736-618,117) for men and NOK 469,588 (348,693-607,114) for women, respectively. If we exclude the richest 1%, the average values are NOK 511,281 (SD=215,739) for men and 499,233 (SD=213,954) for women.

^d Number of non-missing observations for income and education respectively, including missing observation there were 5243 men and 5139 women, in total 10,382.

Mortality models, utilising registry data, were adjusted for 10-year age groups and five-year birth cohorts (cf. Pamuk, 1985).⁹ Statistical significance was set at 5%.

Sensitivity analyses, employing alternative model specifications for income (Supplementary material, Figures S.1 and S.2, available online at <https://doi.org/10.1553/p-d6az-d2j6>), demonstrated minimal impact on estimates.

RII and SII differences were influenced by the baseline level of the lowest category. SII reflected the absolute difference in the outcome between the highest and the lowest possible value of the explanatory variable. For example, a SII of 0.1 for self-reported health indicated a 10 percentage point higher likelihood of having poorer self-reported health in the lowest educated group compared to in the highest educated group.

Results

Descriptive results

Table 1 summarises the samples used in our analyses and highlights differences in education and income distributions between the registry sample and the survey sample. Secondary and tertiary education varied by gender and data source. In the registry sample, 20% of the population had basic education across genders, while a larger share of women (42%) than of men (33%) had tertiary education. In the survey sample, smaller shares of the population had basic education (14% of women, 16% of men), with tertiary education being overrepresented (50% of women, 37% of men).

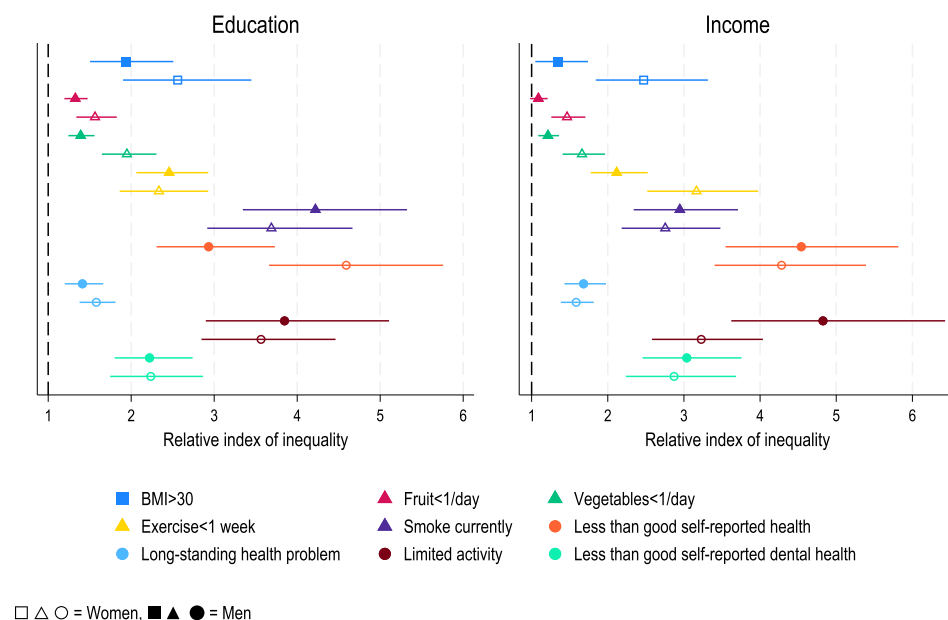
Table 1 indicates a pronounced social gradient in most health outcomes for both men and women. The prevalence difference between women at the top and the bottom of the education distribution was especially large for less-than-good self-reported health (27 percentage points [pp]), activity limitations (22 pp), longstanding health problems (18 pp) and current smoking (21 pp). Among men, absolute differences were largest for current smoking (23 pp) and low physical activity (22 pp). Differences according to income were also substantial, but smaller. Absolute differences in BMI were relatively small, regardless of the measure used. A gradient for both income and education was also observed for all three mortality outcomes (cf. Supplementary material Table S.1 for further details on mortality).

Relative social inequality in health

Figure 1 depicts RIIs for self-reported health behaviours and outcomes among men (solid markers) and women (hollow markers) for education (left panel) and income (right panel). Detailed estimates are reported in Supplementary material Table S.2. Across all health behaviours (triangles), BMI (squares) and self-reported health (circles), the RII coefficients

⁹ Due to a low number of deaths in birth cohorts from 1970 onwards, five-year groups were used up to 1970. Thereafter, 10-year groups were used.

Figure 1 Relative inequality (RII) (with corresponding 95% confidence intervals) among men (solid markers) and women (hollow markers) by education (left) and income (right) for self-reported health behaviours and outcomes

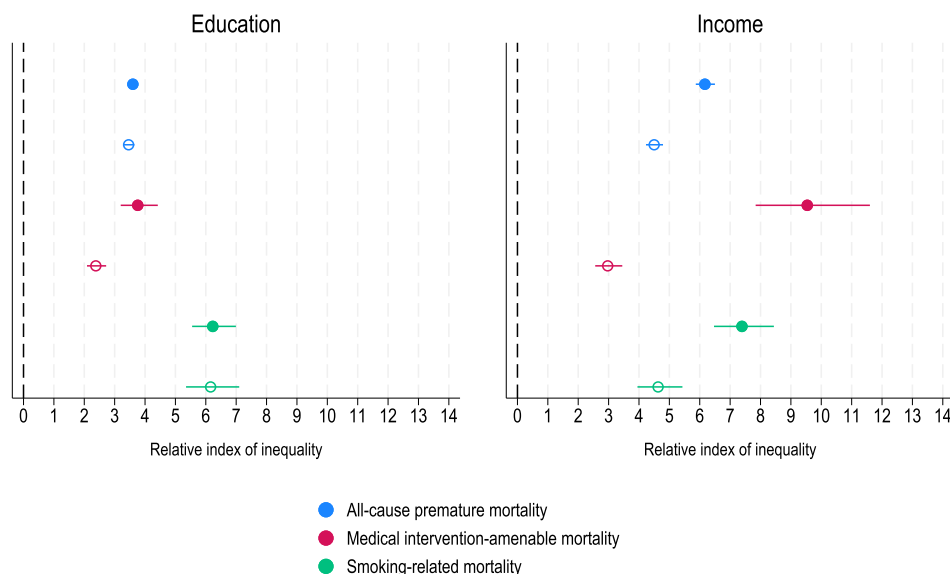


were consistently positive with a 95% confidence interval (CI) above one, indicating statistically significant differences, except for income inequality in fruit intake among men ($\text{RII}=1.09$, $\text{CI } 0.98\text{--}1.21$).¹⁰ Associations were especially strong for less-than-good self-reported health, activity limitations and current smoking.

Figure 2 similarly shows pronounced relative inequalities for all-cause premature mortality, medical intervention-amenable mortality and smoking-related mortality (see Supplementary material Table S.3). Educational attainment (left panel) showed substantial relative inequalities for both genders for all-cause premature mortality ($\text{RII}_{\text{women}} = 3.5$, 95% $\text{CI}=3.3\text{--}3.7$ and $\text{RII}_{\text{men}} = 3.6$, 95% $\text{CI}=3.5\text{--}3.8$), medical intervention-amenable mortality ($\text{RII}_{\text{women}} = 2.4$, 95% $\text{CI}=2.1\text{--}2.7$ and $\text{RII}_{\text{men}} = 3.8$, 95% $\text{CI}=3.2\text{--}4.4$) and especially smoking-related mortality ($\text{RII}_{\text{women}} = 6.2$, 95% $\text{CI}=5.4\text{--}7.1$ and $\text{RII}_{\text{men}} = 6.2$, 95% $\text{CI}=5.5\text{--}7.0$). No substantial gender differences were observed for all-cause premature mortality or smoking-related mortality for education. However, women exhibited lower income-related mortality estimates than men. Among men, income had a strong association with all-cause mortality ($\text{RII}=6.2$, 95% $\text{CI}=5.9\text{--}6.5$), with the greatest inequality observed in deaths amenable to medical intervention ($\text{RII}=9.5$, 95% $\text{CI}=7.8\text{--}11.6$).

¹⁰ $p < 0.01$ for all associations except BMI ($p=0.02$) and low fruit intake ($p=0.11$).

Figure 2 Relative inequality (RII) in mortality (with corresponding 95% confidence intervals) among men (solid markers) and women (hollow markers) by education (left) and income (right)



○ = Women, ● = Men

Note: Medical intervention-amenable mortality includes infectious diseases (A00-B99), cervical cancer (C53), breast cancer (C50), Hodgkin's disease and leukaemia (C81, C91-C95), hypertension (I10-I15), cerebrovascular disease (I60-I69), pneumonia and influenza (J10-J18), appendicitis, hernia and peptic ulcer (K25-K28, K35-K38, K40-K46, K56), cholecystitis and lithiasis (K80-K83) and maternal deaths (O00-O99). Smoking-related causes of death include bronchitis (J40), COPD (J41-J44), bronchiectasis (J47), cancer of the oral cavity, pharynx and oesophagus (C00-C15) and cancer of the trachea, bronchi and lungs (C33-C34, C39).

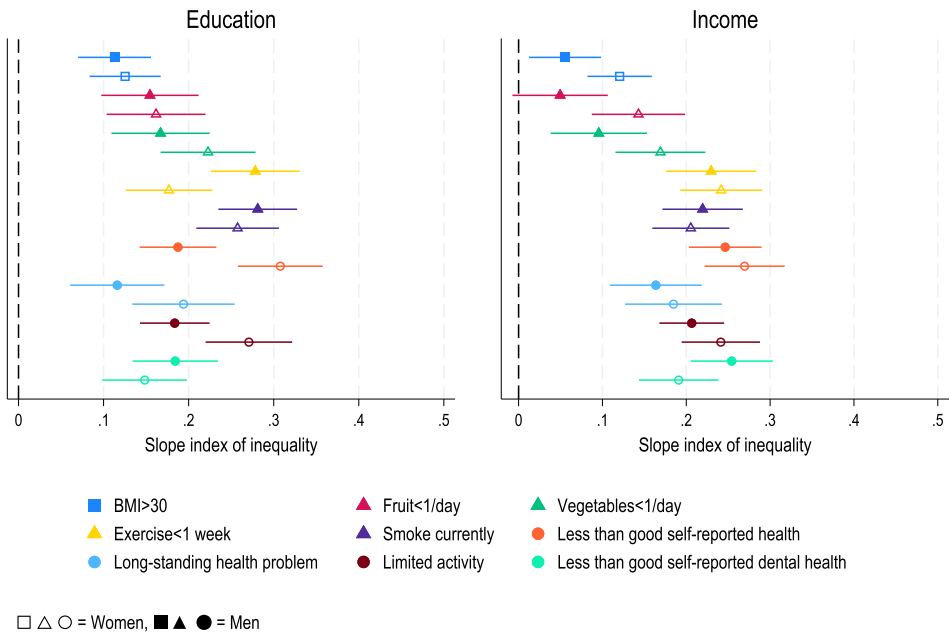
Absolute social inequality in health

Figure 3 illustrates absolute inequality (SII) for self-reported health outcomes, with estimates detailed in Supplementary material Table S.2. Note that the axes are different from the axes in Figure 1, reflecting smaller numerical inequalities on an absolute scale, where values greater than zero indicate statistically significant differences.

The SII patterns differed somewhat from those for RII, with the largest absolute differences observed for smoking, exercise and less-than-good dental health (at least for income) among men, and for smoking, exercise, self-reported health and activity limitations among women. BMI had the smallest SII estimates among both genders, except for income inequalities in fruit intake among men, which was not statistically different from zero ($p=0.09$).

Figure 4. (and Supplementary material Table S.3) shows that compared to relative inequality (Figure 2), estimates for absolute inequality in all-cause mortality (per 1,000) were higher compared to medical intervention-amenable and smoking-related mortality,

Figure 3 Absolute inequality (SII) (with corresponding 95% confidence intervals) among men (solid markers) and women (hollow markers) by education (left) and income (right) for self-reported health behaviours and outcomes

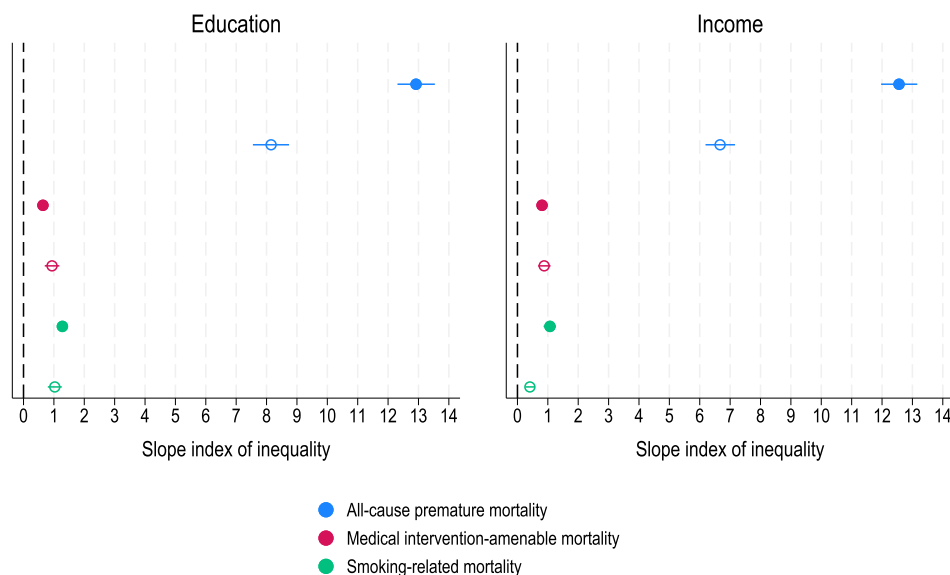


which was partly attributable to low baseline mortality in adults under 70. The large absolute differences for all-cause mortality reflect the higher number of overall deaths compared to deaths from select causes, with a larger impact among men. Among men, absolute estimates for income and education were similar (13/1,000), unlike the relative scale, which showed greater disparities. Among women, SII was higher for education than for income for all-cause and smoking-related mortality.

Discussion

In a European comparative perspective, Norwegian adults generally report good health and have high life expectancy (Goldblatt et al., 2023; OECD, 2019, 2021). However, despite Norway's extensive welfare system and high per capita spending on health, significant socio-economic inequalities in health outcomes remain, indicating that these national-level advantages are not shared equally across socio-economic groups. Specifically, we found that (1) individuals with shorter education and lower income reported poorer health across all behavioural risk factors (except fruit intake among men) and mortality measures; (2) inequalities in behavioural risk factors were similar for education and income, while income-related relative inequalities in all-cause mortality and medical intervention-amenable mortality

Figure 4 Absolute inequality (SII) in mortality (with corresponding 95% confidence intervals) among men (solid markers) and women (hollow markers) by education (left) and income (right)



○ = Women, ● = Men

Note: Slope Index of Inequality is per 1,000. Medical intervention-amenable mortality includes infectious diseases (A00-B99), cervical cancer (C53), breast cancer (C50), Hodgkin's disease and leukaemia (C81, C91-C95), hypertension (I10-I15), cerebrovascular disease (I60-I69), pneumonia and influenza (J10-J18), appendicitis, hernia and peptic ulcer (K25-K28, K35-K38, K40-K46, K56), cholecystitis and lithiasis (K80-K83) and maternal deaths (O00-O99). Smoking-related causes of death include bronchitis (J40), COPD (J41-J44), bronchiectasis (J47), cancer of the oral cavity, pharynx and oesophagus (C00-C15) and cancer of the trachea, bronchi and lungs (C33-C34, C39).

were larger than education-related inequalities, especially for men; (3) inequality between men and women was, to a large degree, comparable in magnitude; and (4) these inequalities were consistent across survey and register data.

Substantial inequalities were observed for several outcomes. Women with the lowest education or income level were more than four times as likely to report poor health (i.e., $RII > 4$), and all-cause mortality was around four times greater (i.e., $RII_{education} = 3.5$ & $RII_{income} = 4.5$), compared to those with the highest education or income level. Among men, RII exceeded four for smoking (education), self-reported health and activity limitations (income) and exceeded three for all-cause mortality. As expected, absolute inequality (SII) for mortality was smaller but significant for all outcomes. Higher education and income levels were, therefore, consistently associated with better health and lower mortality in both absolute and relative terms.

In the self-reported data, daily smoking exhibited a stronger association with inequality than fruit/vegetable intake, obesity or lack of physical activity. This underlines the

significant contribution of smoking to health inequalities in Norway, in contrast to the larger role played by obesity in other European countries (Eikemo et al., 2014). Despite declining smoking rates over the past two decades (Statistics Norway, 2021), a pronounced social gradient persists, and higher education is more strongly associated with successful cessation (Gram et al., 2022). We found substantial socio-economic disparities in smoking-related mortality. Considering the protracted development of smoking-related diseases, such as cardiovascular diseases, lung cancer and COPD, our findings reflect historical lifestyle habits. Despite declining smoking rates, the substantial disparities in self-reported smoking suggest that these diseases will continue to contribute to premature mortality inequalities in the near future, as others have noted (Long et al., 2021). Therefore, while some social groups have benefited from declining smoking rates, others have been left behind.

Significant relative (RII 2.2–3.0) and absolute (SII 0.15–0.26) inequalities in self-reported dental health were observed, although they were smaller than those reported in other Scandinavian countries (Guarnizo-Herreño et al., 2013). Suboptimal dental health is influenced by childhood dental care, diet, financial barriers to oral healthcare and pro-oral health behaviours. Although dental care is free for all Norwegians below age 19, Norwegian adults are generally required to cover the full cost of oral healthcare. Thus, incorporating dental care into the universal healthcare framework could reduce social inequalities and improve overall health, as argued by Lyshol et al. (2022).

Findings in relation to existing literature

Our findings, which describe the situation in recent years, are similar in magnitude to findings from several European countries (Mackenbach et al., 2008; 2015a,b, 2018; 2019a). This likely reflects shared health and welfare systems characteristics and similar societal views on social inequalities, as observed in countries like the UK, the Netherlands, Sweden and Finland (Lahelma et al., 2019). Supporting an earlier study of 22 countries (Mackenbach et al., 2008), we found significantly higher mortality and poorer self-reported health in lower socio-economic groups. While Mackenbach et al. (2008) attributed these disparities to smoking, alcohol and intervention-amenable mortality, our RIIs for poorer self-reported health and current smoking were generally larger. Our finding that income was associated with poor health, particularly in relative terms, is consistent with previous studies (Siegel et al., 2014; Wachtler et al., 2019). Notably, a systematic review found that material factors had a direct impact on health inequalities (Moor et al., 2017).

This study presents a snapshot of the current situation. Longitudinal studies indicate that inequalities have increased over time, although their findings vary depending on whether education or income is considered. While educational inequalities have remained fairly stable (as noted above), many studies have reported a growing trend in income-related disparities (Degerlund Maldt et al., 2019; Pförtner and Elgar, 2016), albeit with some exceptions.

The observed socio-economic disparities in self-reported health and mortality align with the existing literature (Groeniger et al., 2020; Pampel et al., 2010). However, the extent to which physical inactivity, obesity and low fruit/vegetable intake explain the observed

variance in health outcomes continues to be debated. Some authors have argued that the predictive value of these factors is relatively low (cf., for instance, Brunello et al., 2016; Hamplová et al., 2022; Jones and Wildman, 2008), while others have suggested that they play a vital role (cf., for instance, Håmmig et al., 2014; Moor et al., 2017). Smoking, however, stands out as a key factor explaining inequalities in both health and mortality, particularly in countries with high smoking prevalence (Lanari et al., 2022). This observation is in line with Mackenbach et al. (2019b), who identified smoking, low income and high body-weight as critical targets for policies aimed at reducing educational inequalities in life expectancy across Europe.

Strengths and limitations

This study employed established methods (Mackenbach et al., 2008; Moreno-Betancur et al., 2015) to investigate both relative and absolute inequalities, and offers significant policy insights (Hjorthen et al., 2022; Leão et al., 2018; Mackenbach, 2015; van der Wel et al., 2018). The inclusion of both measures, as recommended by previous studies (Mackenbach and Kunst, 1997; Regidor, 2004), provides a more comprehensive understanding of socioeconomic health disparities, and is especially important when the frequency of health problems changes (Regidor, 2004), or in cases in which absolute differences close to zero can be expressed as large relative differences.

Combining survey data from 2015 and 2019 increased the sample size but could have masked year-to-year variations. However, separate year analyses (not shown) revealed no substantial differences in RIIs or SIIs for any behavioural risk factor, except for income-related smoking inequalities among women, where the RII was larger in 2019 than in 2015.

Data on education and income, our primary exposures, were obtained from national registries with objectively derived data for almost the entire population, linked at the individual level to outcome measures. Restricting the sample to adults aged 30–69 ensured that most of the sample had completed their education and were in their prime working years. Household income, representing disposable income after tax and including all income sources, adjusted for household composition, likely provided an accurate reflection of the respondents' economic situation. Although education and income are linked, they influence health through different mechanisms: education promotes healthier lifestyles as a non-material resource, while income reflects material resources and purchasing power, shaping health through access to health care and social comparisons (Huijts et al., 2010). Accounting for both measures was therefore appropriate.

Unlike previous studies focusing on one measure, we consistently highlighted differences by income and education and incorporated multiple data sources. Inequality was prominent in both the population-wide registry data and the representative sample surveys, reinforcing the value of using surveys in tracking social inequalities in health, especially in the absence of registry data. Despite variations in health measures across data sources, previous studies have shown that self-reported health aligns closely with objective health measures (Miller et al., 2022).

This study also has several limitations. We employed a pooled cross-sectional study design, which only allowed for the investigation of associations between socio-economic characteristics and health-related behaviours and mortality, rather than causal inferences. Moreover, we did not address the possible mechanisms behind the gender differences or the variations between RIIs and SIIs based on education versus income. Given the broad selection of health behaviours that were included, these mechanisms were likely diverse. For mortality estimates, both the RIIs and the SIIs were generally larger among men than women, while behavioural risk factors estimates did not show clear gender differences. Nevertheless, having knowledge about associations provides a solid foundation for further work towards meeting the SDGs. Although our analyses presented a snapshot of the current situation, we acknowledge the importance of examining time trends and believe that our findings can serve as a basis for further evaluations in the years leading up to 2030.

Sample surveys generally exhibit selection biases related to both explanatory and outcome variables, as the most disadvantaged groups tend to be underrepresented due to self-selection (as shown in Table 1). To mitigate this problem, we applied survey weights to account for selection bias. Despite these potential biases, comparing survey data with registry data can be informative, even if the outcome measures differ. Self-reported health has been validated in other studies as a reliable measure of both mental and physical health across European countries, reflecting inequalities in mortality as well as in bodily and mental functions between different social groups (Hamplová et al., 2022; Idler and Benyamini, 1997; Moor et al., 2017). Consequently, self-reported health is considered a useful indicator for assessing socio-economic inequalities in health (Baćak and Ólafsdóttir, 2017), as demonstrated in our study.

Whether our findings apply to other contexts with different levels of affluence and inequality warrants further research. Previous studies have shown that economic hardship can exacerbate health inequalities, especially in countries experiencing both austerity and economic recession (Mackenbach et al., 2018). Additionally, our study was limited to the period following the *Great Recession*, which had a smaller effect in Norway than in Eastern and Southern European countries due to Norway's higher level of prosperity and robust welfare schemes (Leão et al., 2018; van der Wel et al., 2018).

Survey data directly capture risk factors like diet and smoking, offering insights that registry data cannot. While we grouped causes of death as smoking-related or amenable to medical intervention, following Mackenbach's classification (2018), misclassification was unavoidable. For example, some intervention-amenable diseases are behaviour-linked, and smoking-related causes exclude conditions like ischaemic heart disease despite its connection to smoking. Thus, while registry data offer unbiased population-level insights without selection bias, we prioritised survey findings in our assessments of risk factors.

The way forward

Norway, as a welfare state, provides its citizens with health and welfare services, affordable higher education and income security (Molven and Ferkis, 2011). The Norwegian Public Health Act (Norwegian Ministry of Health and Care, 2011) further strengthened public

health regulations. Multiple universal programs, such as vaccination, screening and pre- and postnatal care initiatives, are in place, in addition to regulations aimed at limiting consumption of tobacco and alcohol. Similar egalitarian programs have been implemented in countries like the UK, the Netherlands, Sweden and Finland (Lahelma et al., 2019). Reductions in social inequalities in health have, however, also been observed in countries without such programs (Hu et al., 2016).

Despite Norway's history of generous health and welfare policies, our findings suggest that these efforts alone do not mitigate avoidable health inequalities. While social security and public services are essential, these universal measures appear *insufficient* for eliminating socio-economic inequalities in health, particularly in dental health, which is largely unfunded (Hu et al., 2016). Future research should assess inequities in the use of both health and dental services, areas that were not addressed here. As the population ages, ensuring equitable health services across socio-economic groups will become increasingly important for stabilising or reducing socio-economic inequalities in health (Mackenbach et al., 2008; Rydland, 2021; Rydland et al., 2020).

Governments and other stakeholders have recently recognised that while universal public health measures improve overall population health, they may inadvertently *increase* social inequality in health (cf., for instance, McGill et al., 2015 for systematic review results related to eating habits). This paradox is partly attributed to health literacy, as individuals with higher health literacy are more likely to benefit from universal measures (Berkman et al., 2011). Based on our findings, this appears to be the case in Norway as well. Consequently, the focus is gradually shifting towards employing proportionate approaches or specifically targeting at-risk groups. Proportionate universalism implies designing policies that “act across the whole social gradient, to ‘level up the gradient’ while addressing the needs of those in the most vulnerable and excluded situations” (Goldblatt et al., 2023). This strategy ensures that interventions are proportional to the needs of different groups. In Norway, for example, the national cervical screening program has recently been extended to offer in-home tests for individuals who have not attended screenings in the past 10 years. Targeting at-risk groups means focusing on individuals with higher risk exposure, who are often members of vulnerable groups with shared social characteristics (Frohlich and Potvin, 2008). Consequently, public health interventions that take a proportionate or more targeted approach to reaching at-risk groups might be a valuable addition to efforts to reduce socio-economic inequalities in health in welfare societies where universal measures have been the “gold standard”. Further research into such interventions and their effectiveness for various subgroups is, however, warranted.

Our findings can support the endeavours of the UN and European and national authorities aimed at reducing socio-economic inequalities in health, particularly in relation to the UN's Sustainable Development Goal 3 (Good Health and Well-being) and Goal 10 (Reduced Inequalities) (United Nations, 2015). Our results suggest that both sample surveys and registry data are useful in the continued effort, as the results are largely comparable across the data sources. Furthermore, the strong agreement between findings across various health outcomes, regardless of whether they are examined in absolute or in relative terms, suggests that not all measures or methods need always be applied in ongoing policy evaluation work.

Evaluations of how current national, supra-national and sub-national policies mitigate health inequalities are scarce. The optimal design and content of such actions remain unclear, as is the counterfactual scenario of how the situation would develop in the absence of such policies. More evidence is needed to determine which policies work – and for whom, when and where they work – to improve population health, reduce inequalities and limit the unnecessary use of public economic and non-economic (e.g., personnel) resources for ineffective interventions. A recently launched large-scale European Joint Action, JA PreventNCD, aims to address inequalities in cancer and other non-communicable diseases by evaluating policies, actions and interventions with a strong focus on inequality (Klepp, 2023).

Conclusion

Substantial social inequalities in mortality and health-related behaviours exist in Norway across socio-economic measures such as education and household income. These disparities are evident in both absolute and relative terms across multiple indicators of health and behaviours, and irrespective of whether the data originated from surveys or full population registers. The observed inequalities are associated with group-level differences in behavioural lifestyles by education and income. As the current social protections offered by the Norwegian welfare system are shown to be insufficient to *reduce* social inequalities in health, new strategies and fundamental systematic changes appear warranted. To achieve meaningful progress, expanding knowledge on effective policies such as proportionate universalism could provide valuable insights for European policy efforts aimed at reducing socio-economic inequalities in health.

Supplementary material

Available online at <https://doi.org/10.1553/p-d6az-d2j6>

Supplementary file 1. Tables S.1–S.3, Figures S.1–S.2



List of abbreviations

BMI: Body mass index
CPI: Consumer price index
EHIS: European Health Interview Survey
SDGs: Sustainable development goals
RII: Relative Index of Inequality
SII: Slope Index of Inequality

Ethics declaration

The study adhered to the principles of the Helsinki Declaration. Ethical approval for the survey analyses was obtained from SIKT (2023/1333), while ethical approval for the registry analyses was granted by the Regional Ethics Committee (2013/2394).

ORCID iDs

Carl Michael Baravelli  <https://orcid.org/0000-0001-7772-5315>

Tord Finne Vedøy  <https://orcid.org/0000-0001-9603-8940>

Rannveig K. Hart  <https://orcid.org/0000-0003-3140-1942>

Jonas Minet Kinge  <https://orcid.org/0000-0002-2789-6113>

Astri Syse  <https://orcid.org/0000-0003-1754-1594>

References

- Bačák, V., and Ólafsdóttir, S. (2017). Gender and validity of self-rated health in nineteen European countries. *Scandinavian Journal of Public Health*, 45(6), 647–653. <https://doi.org/10.1177/1403494817717405>
- Barth, E., Moene, K., and Pedersen, A. W. (2021). Rising inequality in the egalitarian Nordics. In G. Fischer and R. Strauss (Eds.), *Europe's Income, Wealth, Consumption, and Inequality* (pp. 218–245). Oxford University Press. <https://doi.org/10.1093/oso/9780197545706.003.0006>
- Berkman, N. D., Sheridan, S. L., Donahue, K. E., Halpern, D. J., and Crotty, K. (2011). Low health literacy and health outcomes: An updated systematic review. *Annals of Internal Medicine*, 155(2), 97–107. <https://doi.org/10.7326/0003-4819-155-2-201107190-00005>
- Brunello, G., Fort, M., Schneeweis, N., and Winter-Ebmer, R. (2016). The causal effect of education on health: What is the role of health behaviors? *Health Economics*, 25(3), 314–336. <https://doi.org/10.1002/hec.3141>
- Dahl, E. (1994). Social inequalities in ill-health: the significance of occupational status, education and income—results from a Norwegian survey. *Sociology of Health & Illness*, 16(5), 644–667. <https://doi.org/10.1111/1467-9566.ep11348752>
- Degerlund Maldi, K., San Sebastian, M., Gustafsson, P. E., and Jonsson, F. (2019). Widespread and widely widening? Examining absolute socioeconomic health inequalities in northern Sweden across twelve health indicators. *International Journal for Equity in Health*, 18(1), 197. <https://doi.org/10.1186/s12939-019-1100-5>
- Donaldson, G. W. (1998). Redit scores for analysis and interpretation of ordinal pain data. *European Journal of Pain*, 2(3), 221–227. [https://doi.org/10.1016/S1090-3801\(98\)90018-0](https://doi.org/10.1016/S1090-3801(98)90018-0)
- Eikemo, T. A., Hoffmann, R., Kulik, M. C., Kulhanova, I., Toch-Marquardt, M., Menvielle, G., Looman, C., Jasilionis, D., Martikainen, P., Lundberg, O., and Mackenbach, J. P. (2014). How can inequalities in mortality be reduced? A quantitative analysis of 6 risk factors in 21 European populations. *PloS One*, 9(11), e110952. <https://doi.org/10.1371/journal.pone.0110952>
- Enroth, L., and Fors, S. (2021). Trends in the social class inequalities in disability and self-rated health: repeated cross-sectional surveys from Finland and Sweden 2001–2018. *International Journal of Public Health*, 66, 645513. <https://doi.org/10.3389/ijph.2021.645513>
- European Commission. (2021). Reducing inequalities. Retrieved from https://international-partnerships.ec.europa.eu/policies/human-development/reducing-inequalities_en#x
- Eurostat. (2023). Living conditions in Europe - income distribution and income inequality. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Living_conditions_in_Europe_-_income_distribution_and_income_inequality
- Frohlich, K. L., and Potvin, L. (2008). Transcending the known in public health practice. The inequality paradox: The population approach and vulnerable populations. *American Journal of Public Health*, 98(2), 216–221. <https://doi.org/10.2105/ajph.2007.114777>
- Gallo, V., Mackenbach, J. P., Ezzati, M., Menvielle, G., Kunst, A. E., Rohrmann, S., Kaaks, R., Teucher, B., Boeing, H., Bergmann, M. M., Tjønneland, A., Dalton, S. O., Overvad, K., Redondo, M. L., Agudo, A., Daponte, A., Arriola, L., Navarro, C., Gurrea, A. B., . . . Vineis, P. (2012). Social inequalities and mortality in Europe – results from a large multi-national cohort. *PloS One*, 7(7), e39013. <https://doi.org/10.1371/journal.pone.0039013>

- Goldblatt, P., Castedo, A., Allen, J., Lionello, L., Bell, R., Marmot, M., von Heimburg, D., and Ness, O. (2023). *Rapid review of inequalities in health and wellbeing in Norway since 2014*. Retrieved from <https://www.instituteofhealthequity.org/resources-reports/rapid-review-of-inequalities-in-health-and-wellbeing-in-norway-since-2014>
- Goldman, N. (2001). Social inequalities in health. *Annals of the New York Academy of Sciences*, 954(1), 118–139. <https://doi.org/10.1111/j.1749-6632.2001.tb02750.x>
- Gram, I. T., Antypas, K., Wangberg, S. C., Løchen, M. L., and Larbi, D. (2022). Factors associated with predictors of smoking cessation from a Norwegian internet-based smoking cessation intervention study. *Tobacco Prevention & Cessation*, 8, 38. <https://doi.org/10.18332/tpc/155287>
- Groeniger, J. O., de Koster, W., van der Waal, J., Mackenbach, J. P., Kamphuis, C. B. M., and van Lenthe, F. J. (2020). How does cultural capital keep you thin? Exploring unique aspects of cultural class that link social advantage to lower body mass index. *Sociology of Health and Illness*, 42(7), 1497–1515. <https://doi.org/10.1111/1467-9566.13120>
- Granström, F., Molarius, A., Garvin, P., Elo, S., Feldman, I., and Kristenson, M. (2015). Exploring trends in and determinants of educational inequalities in self-rated health. *Scandinavian Journal of Public Health*, 43(7), 677–686. <https://doi.org/10.1177/1403494815592271>
- Guarnizo-Herreño, C. C., Watt, R. G., Pikhart, H., Sheiham, A., and Tsakos, G. (2013). Socioeconomic inequalities in oral health in different European welfare state regimes. *Journal of Epidemiology and Community Health*, 67(9), 728–735. <https://doi.org/10.1136/jech-2013-202714>
- Gutacker, N., Kinge, J. M., and Olsen, J. A. (2023). Inequality in quality-adjusted life expectancy by educational attainment in Norway: An observational study. *BMC Public Health*, 23(1), 805. <https://doi.org/10.1186/s12889-023-15663-2>
- Hamplová, D., Klusá ek, J., and Mrá ek, T. (2022). Assessment of self-rated health: The relative importance of physiological, mental, and socioeconomic factors. *PloS One*, 17(4), e0267115. <https://doi.org/10.1371/journal.pone.0267115>
- Hjorthen, S. L., Sund, E. R., Skalická, V., Eikemo, T. A., Getz, L. O., and 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 and Medicine*, 292, 1. <https://doi.org/10.1016/j.socscimed.2021.114541>
- Hu, Y., van Lenthe, F. J., Borsboom, G. J., Looman, C. W., Bopp, M., Burström, B., Dzúrová, D., Ekholm, O., Klumbiene, J., Lahelma, E., Leinsalu, M., Regidor, E., Santana, P., de Gelder, R., and Mackenbach, J. P. (2016). Trends in socioeconomic inequalities in self-assessed health in 17 European countries between 1990 and 2010. *Journal of Epidemiology and Community Health*, 70(7), 644–652. <https://doi.org/10.1136/jech-2015-206780>
- Huijts, T., Eikemo, T. A., and Skalická, V. (2010). Income-related health inequalities in the Nordic countries: Examining the role of education, occupational class, and age. *Social Science & Medicine*, 71(11), 1964–1972. <https://doi.org/10.1016/j.socscimed.2010.09.021>
- Hämmig, O., Gutzwiller, F., and Kawachi, I. (2014). The contribution of lifestyle and work factors to social inequalities in self-rated health among the employed population in Switzerland. *Social Science & Medicine*, 121, 74–84. <https://doi.org/10.1016/j.socscimed.2014.09.041>
- Idler, E. L., and Benyamini, Y. (1997). Self-rated health and mortality: A review of twenty-seven community studies. *Journal of Health and Social Behavior*, 38(1), 21–37. <https://doi.org/10.2307/2955359>
- Joint Action Prevent Non-Communicable Diseases Project. (2024). JA PreventNCD. Retrieved from <https://www.preventnecd.eu/>
- Jones, A. M., and Wildman, J. (2008). Health, income and relative deprivation: Evidence from the BHPS. *Journal of Health Economics*, 27(2), 308–324. <https://doi.org/10.1016/j.jhealeco.2007.05.007>
- Kinge, J. M., Dieleman, J. L., Karlstad, Ø., Knudsen, A. K., Klitkou, S. T., Hay, S. I., Vos, T., Murray, C. J. L., and Vollset, S. E. (2023). Disease-specific health spending by age, sex, and type of care in Norway: A national health registry study. *BMC Medicine*, 21(1), 201. <https://doi.org/10.1186/s12916-023-02896-6>
- Kinge, J. M., Vallejo-Torres, L., and Morris, S. (2015). Income related inequalities in avoidable mortality in Norway: A population-based study using data from 1994–2011. *Health Policy*, 119(7), 889–898. <https://doi.org/10.1016/j.healthpol.2015.04.016>

- Klepp, K. I. (2023). JAPreventNCD. *European Journal Public Health*, 33(Suppl 2), ckad160.438. *European Journal of Public Health*, 33(ckad160.438). <https://doi.org/10.1093/eurpub/ckad160.438>
- Kunst, A. E., Bos, V., Lahelma, E., Bartley, M., Lissau, I., Regidor, E., Mielck, A., Cardano, M., Dalstra, J. A., Geurts, J. J., Helmert, U., Lennartsson, C., Ramm, J., Spadea, T., Stronegger, and Mackenbach, J. P. (2005). Trends in socioeconomic inequalities in self-assessed health in 10 European countries. *International Journal of Epidemiology*, 34(2), 295–305. <https://doi.org/10.1093/ije/dyh342>
- Lahelma, E., and Arber, S. (1994). Health inequalities among men and women in contrasting welfare states: Britain and three Nordic countries compared. *European Journal of Public Health*, 4(3), 213–226. <https://doi.org/10.1093/eurpub/4.3.213>
- Lahelma, E., Kivelä, K., Roos, E., Tuominen, T., Dahl, E., Diderichsen, F., Elstad, J. I., Lissau, I., Lundberg, O., Rahkonen, O., Rasmussen, N. K., and Yngwe, M. A. (2002). Analysing changes of health inequalities in the Nordic welfare states. *Social Science & Medicine*, 55(4), 609–625. [https://doi.org/10.1016/s0277-9536\(01\)00191-5](https://doi.org/10.1016/s0277-9536(01)00191-5)
- Lahelma, E., Martikainen, P., Laaksonen, M., and Aittomäki, A. (2004). Pathways between socioeconomic determinants of health. *Journal of Epidemiology and Community Health*, 58(4), 327–332. <https://doi.org/10.1136/jech.2003.011148>
- Lahelma, E., Pietiläinen, O., Pentala-Nikulainen, O., Helakorpi, S., and Rahkonen, O. (2019). 36-year trends in educational inequalities in self-rated health among Finnish adults. *SSM - Population Health*, 9, 100504. <https://doi.org/10.1016/j.ssmph.2019.100504>
- Lahelma, E., Rahkonen, O., and Huuhka, M. (1997). Changes in the social patterning of health? The case of Finland 1986–1994. *Social Science and Medicine*, 44(6), 789–799. [https://doi.org/10.1016/s0277-9536\(96\)00186-4](https://doi.org/10.1016/s0277-9536(96)00186-4)
- Lanari, D., Pasqualini, M., and Pieroni, L. (2022). Is it time to quit? Smoking persistence and self-rated health. *Journal of Population Ageing*, 15(2), 363–380. <https://doi.org/10.1007/s12062-020-09292-5>
- Leão, T., Campos-Matos, I., Bamba, C., Russo, G., and Perelman, J. (2018). Welfare states, the Great Recession and health: Trends in educational inequalities in self-reported health in 26 European countries. *PloS One*, 13(2), e0193165. <https://doi.org/10.1371/journal.pone.0193165>
- Long, D., Mackenbach, J., Martikainen, P., Lundberg, O., Bronnum-Hansen, H., Bopp, M., Costa, G., Kovács, K., Leinsalu, M., Rodríguez-Sanz, M., Menvielle, G., and Nusselder, W. (2021). Smoking and inequalities in mortality in 11 European countries: A birth cohort analysis. *Population Health Metrics*, 19(1), 3. <https://doi.org/10.1186/s12963-021-00247-2>
- Lyshol, H., Grøtvedt, L., Fagerhaug, T. N., Feuerherm, A. J., Jakhell, G., and Sen, A. (2022). A study of socioeconomic inequalities in self-reported oral and general health in South-East Norway. *Scientific Reports*, 12(1), 13721. <https://doi.org/10.1038/s41598-022-18055-5>
- Mackenbach, J. P. (2015). Should we aim to reduce relative or absolute inequalities in mortality? *European Journal of Public Health*, 25(2), 185–185. <https://doi.org/10.1093/eurpub/cku217>
- Mackenbach, J. P. (2017). Nordic paradox, Southern miracle, Eastern disaster: Persistence of inequalities in mortality in Europe. *European Journal of Public Health*, 27(suppl_4), 14–17. <https://doi.org/10.1093/eurpub/ckx160>
- Mackenbach, J. P. (2019). Health inequalities in Europe. How does Norway compare? *Scandinavian Journal of Public Health*, 47(6), 666–671. <https://doi.org/10.1177/1403494819857036>
- Mackenbach, J. P., Kulhánová, I., Bopp, M., Deboosere, P., Eikemo, T. A., Hoffmann, R., Kulik, M. C., Leinsalu, M., Martikainen, P., Menvielle, G., Regidor, E., Wojtyniak, B., and Lundberg, O. (2015a). Variations in the relation between education and cause-specific mortality in 19 European populations: A test of the “fundamental causes” theory of social inequalities in health. *Social Science and Medicine*, 127, 51–62. <https://doi.org/10.1016/j.socscimed.2014.05.021>
- Mackenbach, J. P., Kulhánová, I., Menvielle, G., Bopp, M., Borrell, C., Costa, G., Deboosere, P., Esnaola, S., Kalediene, R., Kovacs, K., Leinsalu, M., Martikainen, P., Regidor, E., Rodríguez-Sanz, M., Strand, B. H., Hoffmann, R., Eikemo, T. A., Östergren, O., Lundberg, O., and Eurothine and EURO-GBD-SE consortiums. (2015b). Trends in inequalities in premature mortality: A study of 3.2 million deaths in 13 European countries. *Journal of Epidemiology and Community Health*, 69(3), 207–217; discussion 205–206. <https://doi.org/10.1136/jech-2014-204319>

- Mackenbach, J. P., and Kunst, A. E. (1997). Measuring the magnitude of socio-economic inequalities in health: An overview of available measures illustrated with two examples from Europe. *Social Science & Medicine*, 44(6), 757–771. [https://doi.org/10.1016/S0277-9536\(96\)00073-1](https://doi.org/10.1016/S0277-9536(96)00073-1)
- Mackenbach, J. P., Kunst, A. E., Cavelaars, A. E., Groenhouf, F., and Geurts, J. J. (1997). Socioeconomic inequalities in morbidity and mortality in western Europe. The EU Working Group on Socioeconomic Inequalities in Health. *Lancet*, 349(9066), 1655–1659. [https://doi.org/10.1016/S0140-6736\(96\)07226-1](https://doi.org/10.1016/S0140-6736(96)07226-1)
- Mackenbach, J. P., Valverde, J. R., Bopp, M., Brønnum-Hansen, H., Costa, G., Deboosere, P., Kalediene, R., Kovács, K., Leinsalu, M., Martikainen, P., Menvielle, G., Rodriguez-Sanz, M., and Nusselder, W. J. (2019a). Progress against inequalities in mortality: Register-based study of 15 European countries between 1990 and 2015. *European Journal of Epidemiology*, 34(12), 1131–1142. <https://doi.org/10.1007/s10654-019-00580-9>
- Mackenbach, J. P., Stirbu, I., Roskam, A.-J. R., Schaap, M. M., Menvielle, G., Leinsalu, M., and Kunst, A. E. (2008). Socioeconomic inequalities in health in 22 European countries. *New England Journal of Medicine*, 358(23), 2468–2481. <https://doi.org/10.1056/NEJMsa0707519>
- Mackenbach, J. P., Valverde, J. R., Artnik, B., Bopp, M., Brønnum-Hansen, H., Deboosere, P., Kalediene, R., Kovács, K., Leinsalu, M., Martikainen, P., Menvielle, G., Regidor, E., Rychta íková, J., Rodriguez-Sanz, M., Vineis, P., White, C., Wojtyniak, B., Hu, Y., and Nusselder, W. J. (2018). Trends in health inequalities in 27 European countries. *Proceedings of the National Academy of Sciences*, 115(25), 6440–6445. <https://doi.org/10.1073/pnas.1800028115>
- Mackenbach, J. P., Valverde, J. R., Bopp, M., Brønnum-Hansen, H., Deboosere, P., Kalediene, R., Kovács, K., Leinsalu, M., Martikainen, P., Menvielle, G., Regidor, E., and Nusselder, W. J. (2019b). Determinants of inequalities in life expectancy: An international comparative study of eight risk factors. *Lancet Public Health*, 4(10), e529–e537. [https://doi.org/10.1016/s2468-2667\(19\)30147-1](https://doi.org/10.1016/s2468-2667(19)30147-1)
- Marmot, M. G., Rose, G., Shipley, M., and Hamilton, P. J. (1978). Employment grade and coronary heart disease in British civil servants. *Journal of Epidemiology and Community Health* 32(4), 244–249. <https://doi.org/10.1136/jech.32.4.244>
- McGill, R., Anwar, E., Orton, L., Bromley, H., Lloyd-Williams, F., O’Flaherty, M., Taylor-Robinson, D., Guzman-Castillo, M., Gillespie, D., Moreira, P., Allen, K., Hyseni, L., Calder, N., Petticrew, M., White, M., Whitehead, M., and Capewell, S. (2015). Are interventions to promote healthy eating equally effective for all? Systematic review of socioeconomic inequalities in impact. *BMC Public Health*, May 2; 15–457. <https://doi.org/10.1186/s12889-015-1781-7>
- Meld. St. 15 (2022–2023). (2023). *Folkhelsemeldinga. Nasjonal strategi for utjamning av sosiale helseforskjellar*. Oslo: Helse- og omsorgsdepartementet. Retrieved from <https://www.regjeringen.no/contentassets/918eb71926fc44c8802fe3c2e0b9a75a/nn-no/pdfs/stm202220230015000dddpdfs.pdf>
- Miller, A. C., O’Reilly, D., Kee, F., Cruise, S., and Young, I. (2022). Multimorbidity, activity limitation and self-reported health all predict mortality risk, but better measures were required. *Journal of Clinical Epidemiology*, 144, 144–162. <https://doi.org/10.1016/j.jclinepi.2021.12.010>
- Molven, O., and Ferkis, J. (2011). *Healthcare, welfare and law: Health legislation as a mirror of the Norwegian welfare state*. Gyldendal.
- Moor, I., Spallek, J., and Richter, M. (2017). Explaining socioeconomic inequalities in self-rated health: A systematic review of the relative contribution of material, psychosocial and behavioural factors. *Journal of Epidemiology and Community Health*, 71(6), 565–575. <https://doi.org/10.1136/jech-2016-207589>
- Moreno-Betancur, M., Latouche, A., Menvielle, G., Kunst, A. E., and Rey, G. (2015). Relative index of inequality and slope index of inequality: A structured regression framework for estimation. *Epidemiology*, 26(4), 518–527. <https://doi.org/10.1097/ede.0000000000000311>
- Morton, S., Pencheon, D., and Squires, N. (2017). Sustainable Development Goals (SDGs), and their implementation: A national global framework for health, development and equity needs a systems approach at every level. *British Medical Bulletin*, 124(1), 81–90. <https://doi.org/10.1093/bmb/ldx031>
- Muller, A. (2002). Education, income inequality, and mortality: a multiple regression analysis. *British Medical Journal*, 324(7328), 23–25. <https://doi.org/10.1136/bmj.324.7328.23>
- Newson, R. (2012). *WRIDIT: Stata module to generate weighted ridsits*. Boston College. Department of Economics. Retrieved from <https://ideas.repec.org/c/boc/bocode/s457427.html>

- Norwegian Ministry of Health and Care (2011). The Norwegian Public Health Act. https://www.regjeringen.no/globalassets/upload/hod/hoeringer-fha_fos/123.pdf
- OECD. (2013). Framework for integrated analysis. In *OECD framework for statistics on the distribution of household income, consumption and wealth*, OECD Publishing (pp. 171–192).
- OECD. (2019). *Health for everyone? Social inequalities in health and health systems*. <https://doi.org/10.1787/3c8385d0-en>
- OECD. (2021). *Health at a glance 2021. OECD indicators*. <https://doi.org/10.1787/ae3016b9-en>
- Pampel, F. C., Krueger, P. M., and Denney, J. T. (2010). Socioeconomic disparities in health behaviors. *Annual Review of Sociology*, 36(1), 349–370. <https://doi.org/10.1146/annurev.soc.012809.102529>
- Pamuk, E. R. (1985). Social class inequality in mortality from 1921 to 1972 in England and Wales. *Population Studies*, 39(1), 17–31. <https://doi.org/10.1080/0032472031000141256>
- Pförtner, T. K., and Elgar, F. J. (2016). Widening inequalities in self-rated health by material deprivation? A trend analysis between 2001 and 2011 in Germany. *Journal of Epidemiology and Community Health*, 70(1), 82–89. <https://doi.org/10.1136/jech-2015-205948>
- Regidor, E. (2004). Measures of health inequalities: Part 2. *Journal of Epidemiology and Community Health*, 58(11), 900–903. <https://doi.org/10.1136/jech.2004.023036>
- Rydland, H. T. (2021). Medical innovations can reduce social inequalities in health: An analysis of blood pressure and medication in the HUNT study. *Health Sociology Review*, 30(2), 171–187. <https://doi.org/10.1080/14461242.2020.1811748>
- Rydland, H. T., Fjær, E. L., Eikemo, T. A., Huijts, T., Bambra, C., Wendt, C., Kulhánová, I., Martikainen, P., Dibben, C., Kal dien, R., Borrell, C., Leinsalu, M., Bopp, M., and Mackenbach, J. P. (2020). Educational inequalities in mortality amenable to healthcare. A comparison of European healthcare systems. *PloS One*, 15(7), e0234135. <https://doi.org/10.1371/journal.pone.0234135>
- Siegel, M., Vogt, V., and Sundmacher, L. (2014). From a conservative to a liberal welfare state: Decomposing changes in income-related health inequalities in Germany, 1994–2011. *Social Science & Medicine*, 108, 10–19. <https://doi.org/10.1016/j.socscimed.2014.02.022>
- St.meld. nr. 20 (2006–2007). (2007). *Nasjonal strategi for å utgjve sosiale helseforskjeller*. Helse- og omsorgsdepartementet, Retrieved from <https://www.regjeringen.no/no/dokumenter/Stmeld-nr-20-2006-2007-/id449531/>
- StataCorp LLC. (2023). Stata/SE 18.0 for Windows (64-bit x86-64).
- Statistics Norway. (2016). *Survey on Living Conditions 2015: Health, care and social relations*. Retrieved from www.ssb.no/en/helseforhold
- Statistics Norway. (2020). *Survey on Living Conditions 2019: Health, care and social relations*. Retrieved from www.ssb.no/en/helseforhold
- Statistics Norway. (2021). *This is Norway 2021*. Retrieved from <https://www.ssb.no/en/befolkning/folketall/artikler/this-is-norway-2021>
- Strand, B. H., Groholt, E. K., Steingrimsdottir, O. A., Blakely, T., Graff-Iversen, S., and Naess, O. (2010). Educational inequalities in mortality over four decades in Norway: Prospective study of middle aged men and women followed for cause specific mortality, 1960–2000. *British Medical Journal*, 340, c654. <https://doi.org/10.1136/bmj.c654>
- Townsend, P., and Davidson, N. (Eds.). (1982). *Inequalities in health: The Black report*. Penguin.
- United Nations. (2015). *Sustainable Development Goals*. Retrieved from <https://www.un.org/sustainabledevelopment/>
- United Nations Development Programme. (2024). *Human Development Report 2023–24: Breaking the gridlock: Reimagining cooperation in a polarized world*. Retrieved from <https://hdr.undp.org/content/human-development-report-2023–24>
- van der Wel, K. A., Saltkjel, T., Chen, W.-H., Dahl, E., and Halvorsen, K. (2018). European health inequality through the ‘Great Recession’: Social policy matters. *Sociology of Health and Illness*, 40(4), 750–768. <https://doi.org/10.1111/1467-9566.12723>
- von dem Knesebeck, O., Verde, P. E., and Dragano, N. (2006). Education and health in 22 European countries. *Social Science and Medicine*, 63(5), 1344–1351. <https://doi.org/10.1016/j.socscimed.2006.03.043>

- Wachtler, B., Hoebel, J., and Lampert, T. (2019). Trends in socioeconomic inequalities in self-rated health in Germany: A time-trend analysis of repeated cross-sectional health surveys between 2003 and 2012. *BMJ Open*, 9(9), e030216. <https://doi.org/10.1136/bmjopen-2019-030216>
- WHO Regional Office for Europe. (2025). *European health report 2024: Keeping health high on the agenda*. Retrieved from <https://iris.who.int/bitstream/handle/10665/380381/9789289061704-eng.pdf?sequence=2>
- World Health Organisation. (2020). *Healthy diet*. Retrieved from <https://www.who.int/news-room/fact-sheets/detail/healthy-diet>
- World Health Organisation. (2025). *Global Health Observatory data repository. Compliance with the international health regulations. Estimates by country*. Retrieved from <https://apps.who.int/gho/data/view.main.UHCIHRv?lang=en>
- Yngwe, M. A., Diderichsen, F., Whitehead, M., Holland, P., and Burström, B. (2001). The role of income differences in explaining social inequalities in self rated health in Sweden and Britain. *Journal of Epidemiology and Community Health*, 55(8), 556–561. <https://doi.org/10.1136/jech.55.8.556>