NIPH
Norwegian Institute of Public Health

REPORT

2021

COVID-19:

COVID-19: Persons tested, confirmed cases and associated hospitalizations by education and income

Kristian Bandlien Kraft
Ingeborg Hess Elgersma
Angela S Labberton
Thor Indseth
Anna Godøy

Publisher Norwegian Institute of Public Health
Division for Health Services

Title COVID-19: Persons tested, confirmed cases and associated hospitalizations by education and income

Norsk tittel Covid-19: personer testet, påviste smittetilfeller og relaterte innleggelser etter utdanning og inntekt

Responsible Camilla Stoltenberg, Director-General

Authors Kristian Bandlien Kraft
Ingeborg Hess Elgersma
Angela S Labberton
Thor Indseth
Anna Godøy

ISBN 978-82-8406-255-6

Publication type NIPH-report

Citation Kraft KB, Elgersma IH, Labberton AS, Indseth T, Godøy A. COVID-19: Persons tested, confirmed cases and associated hospitalizations by education and income. [Covid-19: personer testet, påviste smittetilfeller og relaterte innleggelser etter utdanning og inntekt] Report 2021. Oslo: Norwegian Institute of Public Health, 2021.

Thanks to: We thank Tord Finne Vedøy, Rannveig Kaldager Hart, Lars Østby and Kjetil Telle for valuable and constructive feedback on earlier drafts of this report.

Table of Contents

Key messages

Persons with low education and persons with low household income have been hit harder by the COVID-19 pandemic than the rest of the population. Groups with low education and income have in general been overrepresented in confirmed cases, hospitalizations, invasive ventilation, and deaths related to COVID-19, compared to groups with higher education and higher household income. Persons with higher education and persons with higher household income were overrepresented in confirmed cases and related hospitalizations in the beginning of the first wave of the pandemic, while persons with low education and low household income have had the highest relative numbers of confirmed cases and related hospitalizations during the rest of the study period (until May 2021). There was a positive correlation between increasing education from below upper secondary education to university/college education and test rate. For income, the relationship after 15th June 2020 was slightly S-shaped, with generally higher test rate in the higher income deciles compared to the lower income deciles.

When we adjust for age, sex, municipality of residence and country of birth, the differences in confirmed cases and related hospitalizations decrease, however are rarely eliminated. People with lower education remain slightly overrepresented in confirmed cases and related hospitalizations also after adjustment. However, the overrepresentation of confirmed cases among people with lower household income was fully attenuated after adjustments. The highest income groups still had a somewhat lower hospitalisation rate. The positive relationship between test rate and education (from below upper secondary education to university/college education), and between testing rate and household income remained after adjustments. Overall, adjustment for country of birth made the most difference to the results, especially for the category undisclosed/no education, which was predominantly made up of immigrants.

This report demonstrates that the COVID-19 pandemic has hit people with low education and household income disproportionately, although adjustment for age, sex, municipality of residence and country of birth decreases the differences. We have not fully examined possible reasons why some groups are overrepresented, but family and household structure, employment, health literacy, delayed access to health services or underlying diseases are discussed as underlying reasons. It will be important to obtain more knowledge about these or other mechanisms behind the overrepresentation in future studies.

Executive summary

Introduction
Reports from several countries indicate that people with low education and income are more likely to be affected by COVID-19. In this report we investigate how education level and household income are related to test activity, confirmed cases, hospitalizations, invasive ventilation, and death related to COVID-19 in Norway.

Methods
We have utilized the nation-wide emergency preparedness register, BeredtC19, which contains individual-level data covering the entire Norwegian population. The study population consists of individuals with a personal identification number, alive and registered as residents per 1st March 2020 and are aged 25 years or older. The study period was February 2020 to May 2021. The exposure variables, highest attained education and household income after tax (equivalent income), are operationalised, respectively, into five categories for education, and into deciles for household income. Outcomes studied were test activity (being tested and share of positive tests among those tested), laboratory confirmed cases, related hospitalizations, use of invasive ventilation and death. We have used both descriptive analyses and linear regressions. For the outcomes test activity, confirmed cases, and hospitalization, we adjust for age, sex, municipality of residence and country of birth.

Results
The sample comprised 3 882 249 persons, of which 1 864 860 were tested at least once, 75 698 were confirmed cases, 8 222 hospitalizations, 821 received invasive ventilation, and 710 died. In total, 20 % had attained below upper secondary education and 37 % university or college education. The median household income was 644 143 NOK. The lowest income decile and the undisclosed/no education group were on average younger compared to the other categories. Immigrants made up 93 % of those in the undisclosed/no education group and 40 % of the 1st (lowest) income decile.

There was a positive correlation between increasing education from below upper secondary education to university/college education and test rate, which remained after adjustments. For household income, the relationship after 15th June 2020 was slightly S-shaped, with generally higher testing rates in the higher income deciles compared to the lower income deciles. After adjustment there was a clear positive relationship between household income and testing rate.

Both lower education level and household income were associated with elevated risk of infection and with more severe disease (hospitalization, invasive ventilation, and death). Persons in the three lowest household income deciles and those with a below upper secondary education or undisclosed/no education have been hit hardest. The differences between the different education and income groups in confirmed cases and related hospitalizations decrease when we adjust for age, sex, municipality of residence and country of birth. For confirmed cases, the differences between household income deciles were fully attenuated. For other outcomes, differences were somewhat decreased, however there were still clear trends even after adjustment. Adjusting for immigrant status (country of birth) made the largest impact overall, especially for the category undisclosed/no education, which was predominantly immigrants.

Discussion
These findings correspond with other reports and studies on the relationship between COVID-19 (and health in general) and education and income. This report does not empirically examine why people with low education and low household income have been disproportionally affected, but

factors such as working conditions, living conditions, health literacy, delayed access to health services or underlying diseases are suggested as possible mechanisms.

Conclusion
Individuals with lower education and household income have had higher rates of confirmed cases, hospitalization, invasive ventilation and deaths related to COVID-19. When we adjust for age, sex, municipality of residence and country of birth, differences between the groups are reduced, but rarely eliminated. Of the factors included, country of birth had the largest impact in accounting for the differences between the education and income groups. Going forward, it will be important to obtain more knowledge about the causes and mechanisms behind the observed overrepresentation.

Hovedbudskap (norsk)

Personer med lav utdanning og personer med lav husholdningsinntekt har blitt rammet hardere av pandemien enn resten av befolkningen. Lavt utdannede og lavinntektsgrupper har generelt vært overrepresentert i påvist smitte, innleggelser, respiratorbruk og død relatert til covid-19 sammenlignet med høyt utdannede og høyinntektsgrupper. Personer med høy utdanning og personer med høy inntekt var overrepresentert i påvist smitte og relaterte innleggelser i begynnelsen av den første bølgen av pandemien, mens personer med lav utdanning og husholdningsinntekt har hatt høyest tall i påvist smitte og relaterte innleggelser i resten av studieperioden (til og med mai 2021). Det var en positiv sammenheng mellom økende utdanning (fra grunnskole til universitet/høgskole) og andel testede. For inntekt var sammenhengen svakt S-formet etter 15. juni 2020, med generelt høyere andel testede i de øvre inntektsdesilene sammenlignet med de nedre.

Når vi justerer for alder, kjønn, bostedskommune og fødeland reduseres forskjellene i påvist smitte og relaterte innleggelser. Personer med lav utdanning er likevel noe overrepresentert i påvist smitte og relaterte innleggelser etter justering. For husholdningsinntekt derimot, svekker justeringen hele overrepresentasjonen av påvist smitte i lavere inntektsgrupper. De høyeste inntektsgruppene har fortsatt en lavere andel relaterte innleggelser etter justering. Det er fortsatt en positiv sammenheng mellom andel testede og utdanning (fra grunnskole til universitet/høgskole), og mellom andel testede og husholdningsinntekt. Fødeland var den faktoren som generelt hadde mest betydning for endringene mellom modellene, spesielt for gruppen uoppgitt/uten utdanning som hovedsakelig består av innvandrere.

Denne rapporten viser at covid-19-pandemien har rammet personer med lav utdanning og husholdningsinntekt hardest, selv om justering for alder, kjønn, bostedskommune og fødeland reduserer forskjellene. Vi har ikke undersøkt årsaker til overrepresentasjonen, men arbeidsforhold, boforhold, helsekompetanse, forsinket tilgang til helsetjenester og underliggende sykdommer har blitt diskutert som underliggende faktorer. Det vil framover bli viktig å skaffe mer kunnskap om årsakene og mekanismene bak denne overrepresentasjonen.

Sammendrag (norsk)

Innledning
Rapporter fra flere land tyder på at personer med lav utdanning og inntekt har større sannsynlighet for å bli rammet av covid-19 enn andre. I denne rapporten undersøker vi hvordan utdanningsnivået og husholdningsinntekt er relatert til testaktivitet, påviste smittetilfeller, sykehusinnleggelser, respiratorbruk og død knyttet til covid-19 i Norge.

Metode
Vi har brukt det nasjonale beredskapsregisteret "BeredtC19" med data på individnivå over hele den norske befolkningen. Studiepopulasjon består av hver person med personnummer, registrert som bosatt 1. mars 2020 og er 25 år eller eldre. Studieperioden var fra februar 2020 til mai 2021. Forklaringsvariablene, høyeste oppnådde utdanning og husholdningsinntekt etter skatt (ekvivalentinntekt), er operasjonalisert i fem utdanningskategorier og ti inntektsdesiler. Utfallene vi har studert er testaktivitet (andel testede og andel av positive tester av de testede), påviste smittetilfeller (med PCR-test), relatert sykehusinnleggelser, respiratorbruk og død. Vi har både brukt deskriptive analyser og lineær regresjon. For utfallsvariablene andel testede, påvist smitte og innleggelser justerer vi for alder, kjønn, bostedskommune og fødeland.

Resultat
Utvalget besto av 3 882 249 personer, hvor 1 864 860 var testet minst en gang, 75 698 fikk påvist smitte, 8 222 var innlagt på sykehus, 821 trengte respiratorbehandling og 710 har dødd. Totalt hadde 20 % oppnådd grunnskole som høyest utdanning, mens 37 % hadde universitet- eller høgskoleutdanning. Median-husholdningsinntekten var 644 143 kr. Den laveste inntektsdesilen og gruppen med uoppgitt eller uten utdanning var i gjennomsnitt yngre enn de andre gruppene. Innvandrere utgjorde 93 % av gruppen med uoppgitt eller uten utdanning, og 40 % av den laveste inntektsdesilen.

Det var en positiv sammenheng mellom økende utdanning (fra grunnskole til universitet/høgskole) og andel testede, som besto også etter justering. For husholdningsinntekt var sammenhengen svakt S-formet etter 15. juni 2020, med generelt høyere andel testede i de øvre inntektsdesilene sammenlignet med de nedre. Etter justering var det en klar positiv sammenheng mellom husholdningsinntekt og andel testede. Generelt var både lavere utdanning og lavere husholdningsinntekt tettere forbundet med en forhøyet risiko for å bli smittet og mer alvorlig sykdom (sykehusinnleggelse, respiratorbruk og død). Personer i de tre laveste inntektsdesilene og de med grunnskole eller uoppgitt/ingen utdanning har blitt rammet hardest. Forskjellene i påviste tilfeller og relaterte innleggelser minsker mellom de ulike inntekts- og utdanningsgruppene når vi justerer for alder, kjønn, bostedskommune og fødeland. For påviste tilfeller er forskjellene mellom inntektsdesilene borte. For de andre utfallene er forskjellene svekket, men det er fortsatt klare mønstre etter justering. Fødeland var den faktoren som generelt hadde mest betydning for endringene mellom modellene, spesielt for gruppen uoppgitt/uten utdanning som hovedsakelig består av innvandrere.

Diskusjon
Disse funnene sammenfaller med andre rapporter og studier over relasjonen mellom covid-19 (og helse generelt) og inntekt og utdanning. Denne rapport undersøker ikke empirisk hvorfor personer med lav utdanning og lav husholdningsinntekt er hardest rammet, men faktorer som familie- og husholdningsstørrelse og sammensetning, arbeidsforhold, boforhold, helsekompetanse, forsinket tilgang til helsetjenester eller underliggende sykdommer er foreslått som mulige mekanismer.

Konklusjon

Personer i den lavere enden av utdannings- og inntektsskalaen er overrepresentert i påviste smittetilfeller, relaterte innleggelser, respiratorbruk og død. Når vi justerer for alder, kjønn, bostedskommune og fødeland reduseres overrepresentasjonen mellom gruppene, men mønstrene forblir de samme. Av faktorene som er inkludert er det fødeland som har den største betydningen i å forstå forskjellene mellom personer med ulike utdanninger og husholdningsinntekter. Fremover vil det være viktig å skaffe mer kunnskap om årsakene og mekanismene bak denne overrepresentasjonen.

Introduction

Reports from several countries indicate that the coronavirus disease 2019 (COVID-19) pandemic has affected certain socioeconomic groups more than others (Vist et al. 2021). This has thus far been little studied in Norway. The Norwegian Institute of Public Health (NIPH) has previously published analyses of occupation and risk of infection and hospitalization (Magnusson et al. 2020, Folkehelseinstituttet 2020a), and a report on COVID-19 among persons born outside of Norway adjusted for socioeconomic factors. These analyses indicated that socioeconomic factors like education and income may be associated with COVID-related outcomes (Indseth et al. 2021). Furthermore, a systematic overview of studies on COVID-19 among groups of different socioeconomic status identified few studies from Nordic countries (Vist et al. 2021).

More knowledge about how infection and disease of SARS-CoV-2, the virus that causes COVID-19, is distributed in different parts of the population, is important for understanding the pandemic, and for local and central authorities' ability to effectively target mitigation strategies. This is crucial in order to protect the most affected groups and ensure that as few people as possible become seriously ill or die due to COVID-19, and to help reduce health inequalities. This knowledge will also be important after the pandemic to better understand how social inequality influences health outcomes.

Socioeconomic position (SEP), or socioeconomic status, is known to be related to inequalities in health. People with lower SEP have, on average, poorer health than those with better SEP. This is the case for many different health conditions, including infectious and non-infectious diseases, chronic diseases, and also for mortality in general (Folkehelseinstituttet 2018, Dalstra et al. 2005, Gallo et al. 2012, Kivimaki et al. 2020, Mackenbach et al. 2016, Mamelund et al. 2021).

The association between SEP and public health outcomes has been thoroughly studied. Fundamental cause theory underlines that the association persists because SEP embodies "an array of resources, such as money, knowledge, prestige, power, and beneficial social connections that protect health no matter what mechanisms are relevant at any given time" (Phelan et al. 2010).

SEP can be operationalized, or measured, in several different ways (Galobardes et al. 2006). Measures of education, income and occupation (or labour market participation) are perhaps most common. Education is a commonly used measure of SEP for health research, and is often used as a proxy for SEP if others are omitted or unavailable. Education is a measure of human capital such as knowledge and information processing ability, which can affect health-related actions and behaviours throughout life, and therefore the individual's health. Education provides skills and competencies and strengthens the ability to transform health information into healthy behaviours such as a healthy diet, physical activity and refraining from smoking. However, education may also to some degree measure family background and other forms of social capital. The opportunity to engage in and complete a longer educational degree may depend on resources available. Educational attainment can have a direct impact on an individual's earning capacity (income). Income is a measure of material resources which may promote, or hinder, health-related choices and behaviours. Access to health services and healthy living environments may also be directly impacted by income. Lastly, occupation measures exposure to working conditions that may affect health.

In the context of the COVID-19 pandemic, all these factors may impact an individual's ability to access, understand, evaluate, and follow rules and regulations to avoid exposure to the virus and further spread of it. Disease severity once infected could also be affected by a person's SEP if the individual's existing health status is poorer, or if there are delays in seeking medical help.

It is therefore likely that both the risk of being infected and the severity of the infection are related to SEP. Previous studies from the NIPH show that persons with certain occupations were more likely to be infected by coronavirus during the first and second waves (Magnusson et al. 2020, Folkehelseinstituttet 2020a). Additionally, structural factors associated with social inequality, such as lacking or delayed access to healthcare, may enable or hamper society's response to the pandemic.

In the following report, we present analyses using individual-level data to study the associations of completed education and household income with test activity, confirmed SARS-CoV-2 infection, related hospitalizations, invasive ventilation, and death. While confirmed cases are closely related to test activity, the other measures of morbidity and mortality are not, and may thus give best measure of the true level of socioeconomic differences in infection.

We focus on data from Norway and the Norwegian context. Internationally, however, it appears that the COVID-19 pandemic has hit economically and socially disadvantaged groups harder. The majority of studies have analysed associations between neighbourhood-level indicators of SEP only. Neighbourhood-level indicators that have been used in existing studies include neighbourhood median income, education, proportion employed, ethnicity, deprivation, and, in the United States of America (USA) particularly, the proportion with medical insurance. International studies show that persons living in poorer and more deprived neighbourhoods in Sweden, USA, United Kingdom (UK), and Brazil have been disproportionally hit in terms of confirmed cases, hospitalizations and/or deaths (Bartelink et al. 2020, Drefahl et al. 2020, Calderón-Larrañaga et al. 2020, Abedi et al. 2021, Public Health England 2020, Li et al. 2021). In Sweden, Drefahl et al. found higher COVID-19-related mortality rates among persons with pre-college education only and among persons in the lowest tertile of individual net income (Drefahl et al. 2020). In Norway, Søegaard and Kan (2021) have investigated associations with aggregated data from 15 city districts in Oslo and found a socioeconomic gradient for infection rates. Due to the low level of socioeconomic inequalities in Norway, we should expect that socio-economic factors have less impact on health in Norway than in countries where differences are more prominent.

The purpose of this report is to provide an overview of how COVID-19 has affected various socioeconomic groups in Norway, specifically across categories of educational attainment and household income. We do not include analyses by occupation in this report, as associations between occupation and COVID-19 have previously been the subject of several other reports and articles by the NIPH (for example, Magnusson et al. 2020, Folkehelseinstituttet 2020a, Kjøllesdal et al. 2021).

In this report, we move beyond most of the previous literature in that we measure socioeconomic status at the individual-level. This enables us to adjust for individual factors that may not be captured at a district or society level. While some Swedish studies have measured socioeconomic characteristics at the individual-level with COVID-19 related mortality as outcome (Bartelink et al. 2020, Drefahl et al. 2020), infection rates, disease outcomes and mitigation strategies differ markedly between the two neighboring countries, and the socioeconomic patterns need not be the same.

We have investigated outcomes related to testing for SARS-CoV-2, the share of those who are tested who have tested positive, confirmed cases, hospitalizations, invasive ventilation and death in different educational and income groups. Furthermore, we aim to assess the robustness of these observed differences by adjusting for different demographic compositions of the groups.

Methods

Design and data sources

We have conducted a nation-wide, registry based observational study using the preparedness registry Beredt C19. Beredt C19 is a national emergency preparedness register established during the COVID-19 pandemic, as a part of the legally mandated responsibilities of the NIPH during epidemics. BeredtC19 contains individual-level data, covering the entire Norwegian population, linked via the unique, personal identification number given to all Norwegian residents at birth or once granted residency. The BeredtC19 data used for this study originated from the Norwegian Surveillance System for Communicable Diseases and laboratory database (all polymerase chain reaction (PCR) tests with test results for SARS-COV-2), Norwegian Patient Registry (all hospital admissions), National Population Register (demographics, municipality of residence), and Statistics Norway (education, household income, country of birth). In addition, we use data on medical risk groups in Beredt C19 that is based on risk conditions for COVID-19 defined by an expert panel (Folkehelseinstituttet 2020b)

Study population and period

The sample includes all persons with a personal identification number in the Norwegian population register, who are registered as residents of Norway per 1st March 2020, and who are aged 25 years or older. Both employed and unemployed residents are included. This includes 3 882 249 persons. Persons who have immigrated to Norway after 2018 or persons who have not been assigned a personal identification number or household identification number have not been included in this sample. Our study therefore does not include workers, tourists and others on short-term stays or migrants without legal residence. Furthermore, persons with missing information about household income are excluded (N=36 026, 0.93%). We include the entire period from the first identified case in February 2020 until 31st May 2021. However, for the analyses on test activity we split the period at 15th June 2020 because of limited test capacity and restrictive test criteria prior to this date. Vaccination against COVID-19 began towards the end of December 2020, and the majority of the adult population received an offer of vaccination during summer 2021. Until 30th May 2021, 38.3% of the population 18 years or older had received at least one dose of a COVID-19 vaccine (Folkehelseinstituttet 2021a), and by 1st August 2021, 83.4% had received at least one dose (Folkehelseinstituttet 2021b). We therefore limit the study period to May 2021 so that any differences in vaccination rates between groups should not have a significant impact on results.

Variables

The primary exposures were highest attained education per 2019 and household income after tax in 2018. Highest attained education was categorized into ‘Below upper secondary’; ‘Upper secondary/vocational’; ‘University/college, short’ (≤ 4 years); ‘University/college, long’ (> 4 years); and ‘Undisclosed/no education’. Upper secondary/vocational was created by merging upper secondary education and tertiary vocational education, since the latter category has only been in use since 2016. Household income was recorded as an equivalised income as annual household income after tax, divided by number of consumptions units (calculated in the EU-scale; see Eurotat 2021) in the household and categorized in deciles. The number of consumption units was calculated on the basis of the number of household members (including members younger than 25 years). Different from the education variable, persons with a missing value on household income were dropped from the sample. This is because household income is operationalised into ten deciles with equal size on a scale and the number dropped are less than one percent of the sample.

The main outcomes of interest were receiving a PCR test for SARS-CoV-2, the share of persons testing positive among those tested, confirmed cases (PCR positive test for SARS-CoV-2), and COVID-19-

related hospital admissions. Testing and infection data were obtained from the Norwegian Surveillance System for Communicable Diseases (MSIS). Hospitalizations were detected by utilizing data from the Norwegian Patient Registry (NPR). COVID-19-related hospitalization is defined (according to national standards) as when a person has tested positive for COVID-19 and been hospitalized (inpatient) at a hospital in Norway during the period between 2 days before to 14 days after the positive test.

Additional outcomes were requiring invasive ventilation and COVID-19 related death. If a person has had more than one hospitalization with COVID-19, the hospitalization requiring invasive ventilation was used. Invasive ventilation was defined by the procedure code GXAV01 for invasive mechanical ventilation ("Respiratorbehandling INA") in the Norwegian Classification of Medical Procedures (NCMP). We do not include other types of ventilatory support. COVID-19-associated death was defined as when a person has died within 30 days after testing positive for COVID-19. Date of death is notifiable and recorded by MSIS. Due to relatively small numbers we do not include these two outcomes in adjusted analyses.

Demographic characteristics included age, sex, municipality of residence, and immigrant status (country of birth). Immigrants were classified according to data and definitions from Statistics Norway, where immigrants are defined as persons who were born abroad with two foreign-born parents. Persons born in Norway, and persons born abroad, with one or two Norwegian-born parents are referred to as the rest of the population, or non-immigrants. Immigrant status is referred to as 'country of birth' in adjusted models.

Statistical analyses

To examine how COVID-19 has affected different educational and income groups, we have used descriptive (bivariate) analyses to describe test activity, confirmed cases, related hospitalizations, invasive ventilation and deaths for different education and household income groups. For confirmed cases and hospitalization, we have presented the development over time. The descriptive analyses show which socioeconomic groups have been hit hardest by the pandemic and how this has changed over time. The difference between both education and income groups may be confounded by other demographic factors, and hence, we used linear regression (OLS) with robust standard errors to adjust for several demographic factors. In addition to an unadjusted model, we therefore have adjusted for the following sets of factors in three separate regression models: 1) age and sex, 2) age, sex and municipality of residence, and 3) age, sex, municipality of residence and country of birth. Because of low numbers for invasive ventilation and deaths, we have only used regression analysis for the outcomes testing, confirmed cases and hospitalization. In regression analyses, the reference category for education was 'Below upper secondary', and for household income the reference category was the 1st decile, i.e. the group of the 10 percent of the population with lowest household income. Regression outputs from the regression models are found in Appendix Tables 7a-f.

In addition to the main analyses, we have included two sets of sensitivity analyses. One of the sensitivity analyses examine the effect of the variable "medical risk group" as a likely mediator in the regression when hospitalization is the outcome variable. The other sensitivity analysis examines the interaction effect between education and household income.

Results

The sample comprised 3 882 249 persons, of which 1 864 860 were tested at least once, 75 698 were confirmed cases, 8 222 hospitalizations, 821 received invasive ventilation, and 710 died. In total, 20.2 % had attained below upper secondary education and 36.7 % university or college education. The median household income was 642 076 NOK. Table 1 shows how the different education and income groups differ in terms of demography and outcomes. Of note, the 1st decile and the undisclosed/no education group were on average younger compared to the other categories. There was a higher share of women in the university/college, short category and in the lower income deciles, and a higher share of men in the undisclosed/no education category and in the higher income deciles. Notably, around 93 % of those in the undisclosed/no education group, and 40 % of the 1st decile, were immigrants. Results for these two categories, especially the undisclosed/no education group, should therefore be interpreted with this in mind.

Table 1. Description of study population by education and household income

	Total (%)	**Mean age (Standard deviation)**	**Female, frequency (%)**	**Living in Oslo, frequency (%)**	**Non-immigrants, frequency (%)**
ENTIRE SAMPLE	3 882 249 (100)	53 (17)	1 933 948 (50)	493 988 (13)	3 213 449 (83)
EDUCATION					
Below upper secondary	780 668 (20)	55 (19)	386 476 (50)	74 647 (10)	629 395 (81)
Upper sec./ vocational	1 529 675 (40)	56 (17)	687 502 (45)	121 434 (8)	1 371 517 (90)
Uni./college short	999 577 (26)	49 (16)	597 201 (60)	160 521 (16)	871 058 (87)
Uni./college long	422 749 (11)	48 (15)	202 337 (48)	109 763 (26)	331 896 (79)
Undisclosed/ No education	137 933 (4)	43 (13)	60 432 (44)	27 623 (20)	9 583 (7)
HOUSEHOLD INCOME					
1st decile	384 624 (10)	46 (19)	202 402 (53)	73 534 (19)	231 577 (60)
2nd decile	384 621 (10)	55 (20)	216 218 (56)	48 299 (13)	291 803 (76)
3rd decile	384 625 (10)	55 (19)	202 054 (53)	40 387 (11)	307 630 (80)
4th decile	384 624 (10)	54 (18)	194 951 (51)	37 418 (10)	319 827 (83)
5th decile	384 618 (10)	53 (17)	191 169 (50)	37 667 (10)	329 102 (86)
6th decile	384 625 (10)	52 (17)	188 479 (49)	38 836 (10)	336 390 (87)
7th decile	384 623 (10)	52 (16)	185 971 (48)	42 130 (11)	341 789 (89)
8th decile	384 623 (10)	52 (15)	182 761 (48)	46 427 (12)	347 191 (90)
9th decile	384 620 (10)	53 (14)	180 342 (47)	52 806 (14)	352 509 (92)
10th decile	384 620 (10)	55 (13)	178 103 (46)	70 334 (18)	355 236 (92)

Test activity by education and household income

We begin by describing differences in test activity, as these differences may explain some of the differences in the number of confirmed cases, since testing is a pre-requisite to identify positive/confirmed cases. A low testing rate or a high share of the tested being positive can indicate that the number of undetected cases is high.

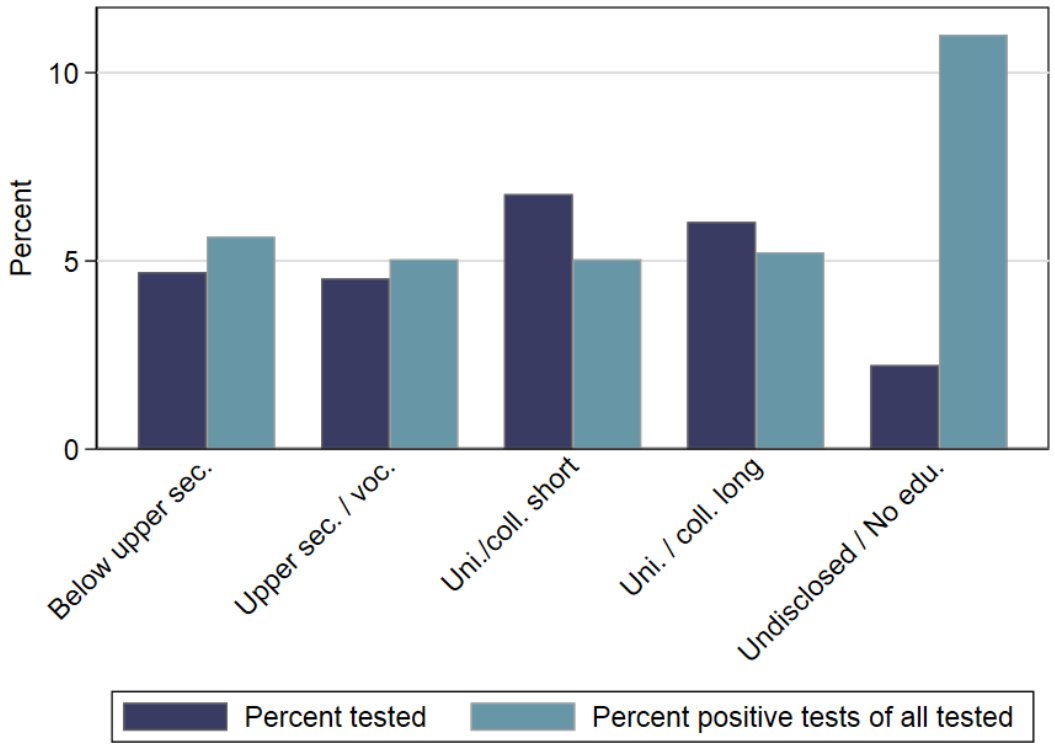
Figures 1a-b show the testing rate and the share of those who are tested who have tested positive, by educational attainment (see also Appendix Table 4a). Before 15th June 2020, the testing rate was higher among those with a higher education level (Figure 1a). After 15th June, this relationship slightly changed, with those with a long college/university education still more prone to test, however those with undisclosed/no education having a higher testing rate than the below secondary and upper secondary/vocational categories. This is likely due to the higher number of confirmed cases in the undisclosed/no education group. After 15th June, persons with undisclosed/no education and below upper secondary education had a higher percentage of positive tests among the people tested (Figure 1b).

Figures 2a-b show the proportion tested at least once and proportion of these who have tested positive, by household income (see also Appendix Table 4b). Before 15th June 2020, the percent tested was slightly lower at each end of the income scale (1st and 10th income decile) (Figure 2a). After 15th June, the distribution was slightly S-shaped, with a higher number of tested, and a lower proportion of those tested who have tested positive, in the higher income deciles compared to the lower income deciles (Figure 2b).

Adjusting for age, sex, municipality of residence and country of birth (Figure 3) reduced the differences in test activity between almost all levels of educational attainment and the reference category (below upper secondary education). However, after adjustment a positive correlation between test activity and increasing education from below secondary to university/college education is still clear. The low testing rate in the undisclosed/no education group may be explained by the high number of immigrants in this group, as adding country of birth to the model (orange triangle), reduces the difference between the undisclosed/no education and reference group to close to zero. In terms of household income, the differences in testing between the reference level (1st income decile) and the other deciles are slightly inflated. Before adjusting for age, sex, municipality of residence and country of birth, the 1st income decile is slightly overrepresented compared to the 2nd and 3rd deciles. After adjustment there is a clear positive relationship between household income and testing rate.

Figure 1. Percent tested at least once and proportion of the tested who have tested positive, by education. a) Until 15th June 2020, and b) After 15th June 2020.

a) Until 15th June 2020



b) After 15th June 2020

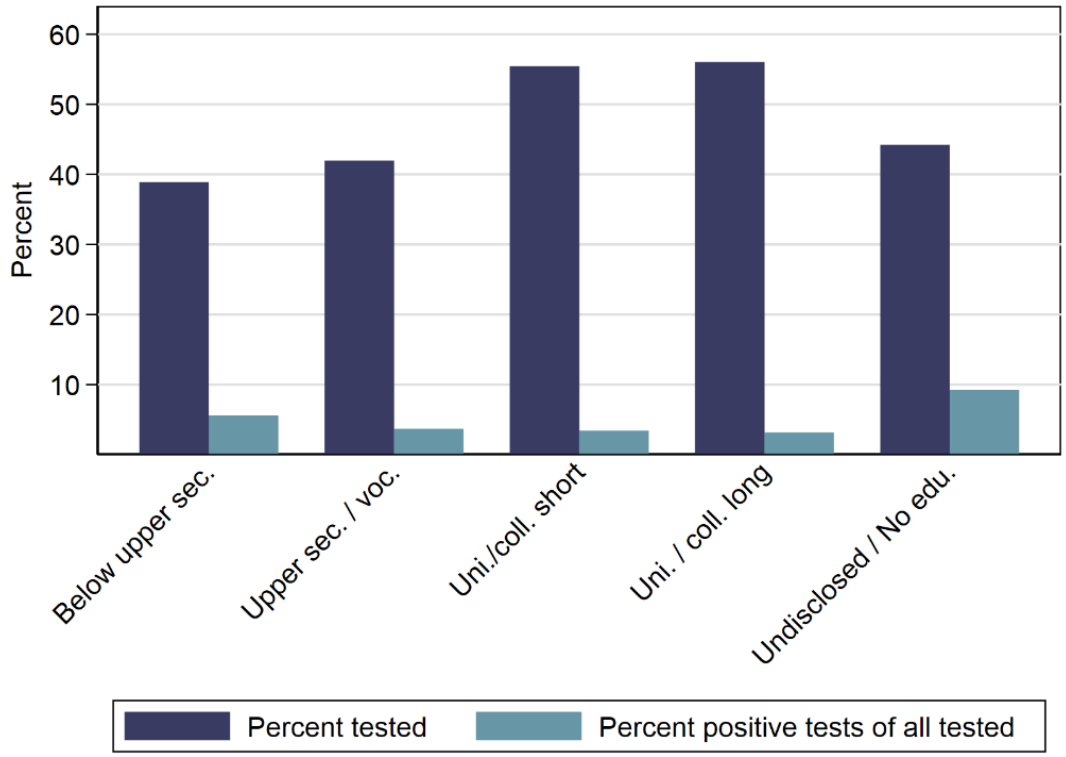
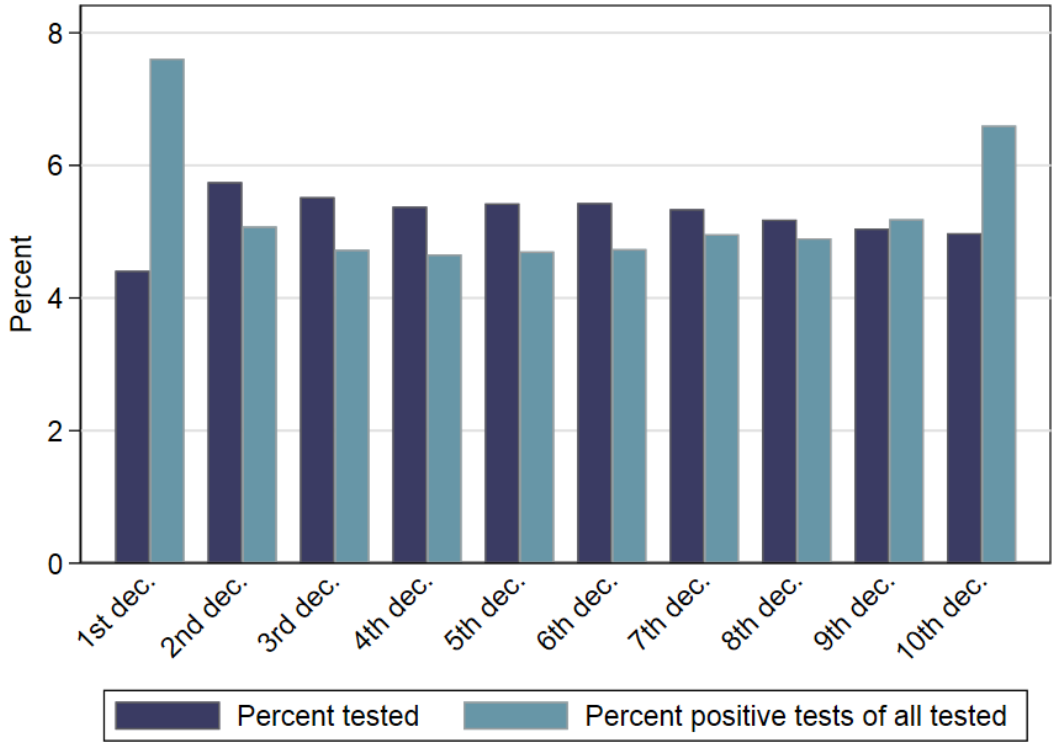


Figure 2. Percent tested at least once and proportion of the tested who have tested positive, by household income. a) Until 15th June 2020, and b) After 15th June 2020.

a) Until 15th June 2020



b) After 15th June 2020

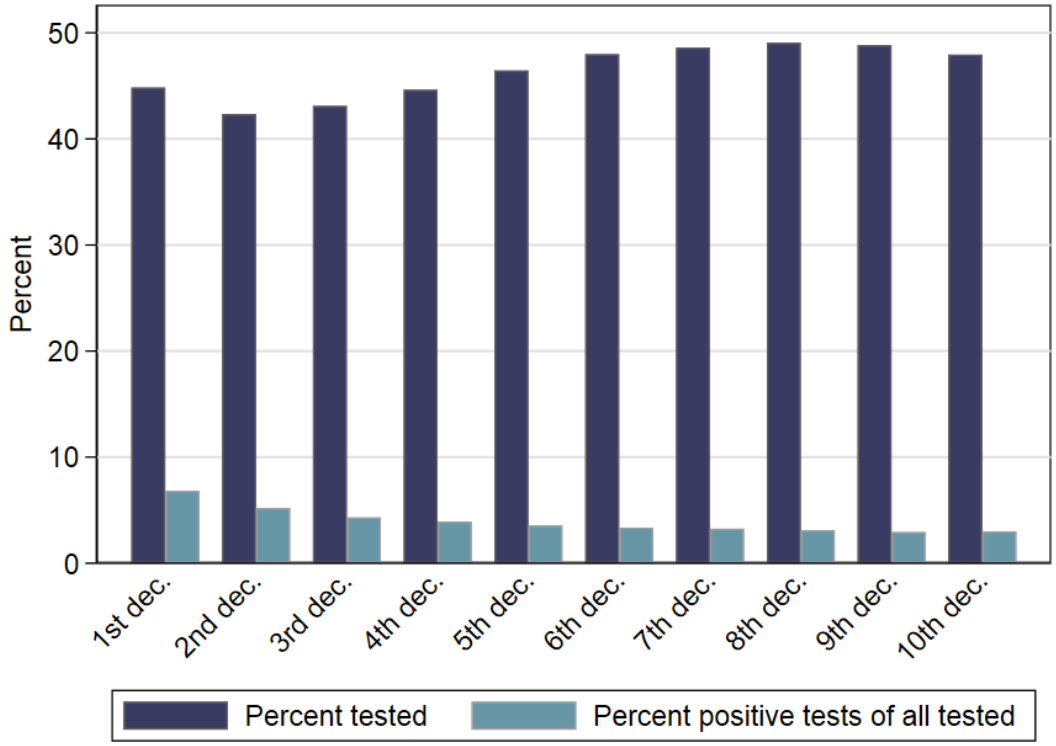
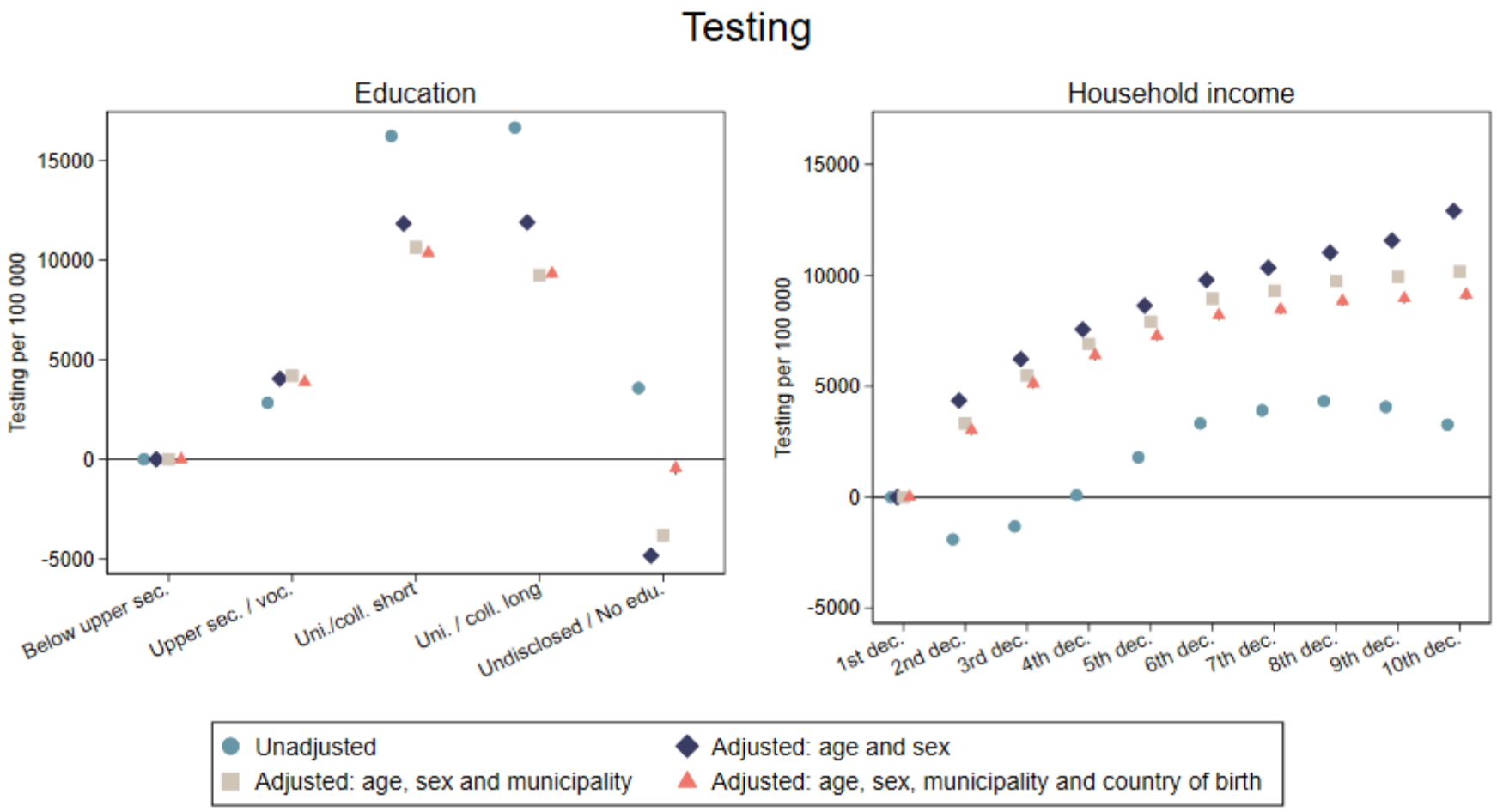


Figure 3. Testing per 100 000 by education and household income category, adjusted for age, sex, municipality of residence and country of birth. Beta-coefficients, reference group: Below upper secondary (left panel), 1st income decile (right panel). The markers represent the difference in testing per 100 000 compared to the reference group standardized to 0.
Period 02.2020 – 05.2021.



Confirmed cases by education and household income

The relative number of confirmed cases was higher among persons with undisclosed/no education, below upper secondary education, and in the 1st, 2nd and 3rd household income deciles (Figure 4 and 6). The differences are large, with more than double the number of cases in the categories with the highest relative number of cases than in the categories with the lowest relative number of cases. The effect is of a similar size for education and household income.

The relative differences between the groups have largely remained constant over time (Figure 5 and 7). However, in the beginning of the pandemic, in March 2020, the numbers were higher among persons with high education and/or income. From April, the number of cases has constantly been higher in the lower education and household income groups. During the second and third wave of the pandemic (from august 2020 to May 2021), persons in the undisclosed/no education group, and persons in the three lowest income deciles, had the largest numbers of confirmed cases.

Figure 8 shows the number of confirmed cases per 1 000 000 by education and household income category after adjustments. Adjusting for age, sex and municipality of residence reduces the difference between the household income and educational attainment groups, but adjusting for country of birth makes the biggest impact. While adjusting for these covariates fully attenuated the difference between the household income deciles, persons with a higher education/college degree remain underrepresented. The relative number of confirmed cases per 100 000 is around 800 less in this group than in the reference group, below upper secondary education.

Figure 4. Confirmed cases per 100 000 by highest completed education.
Period 02.2020 – 05.2021.

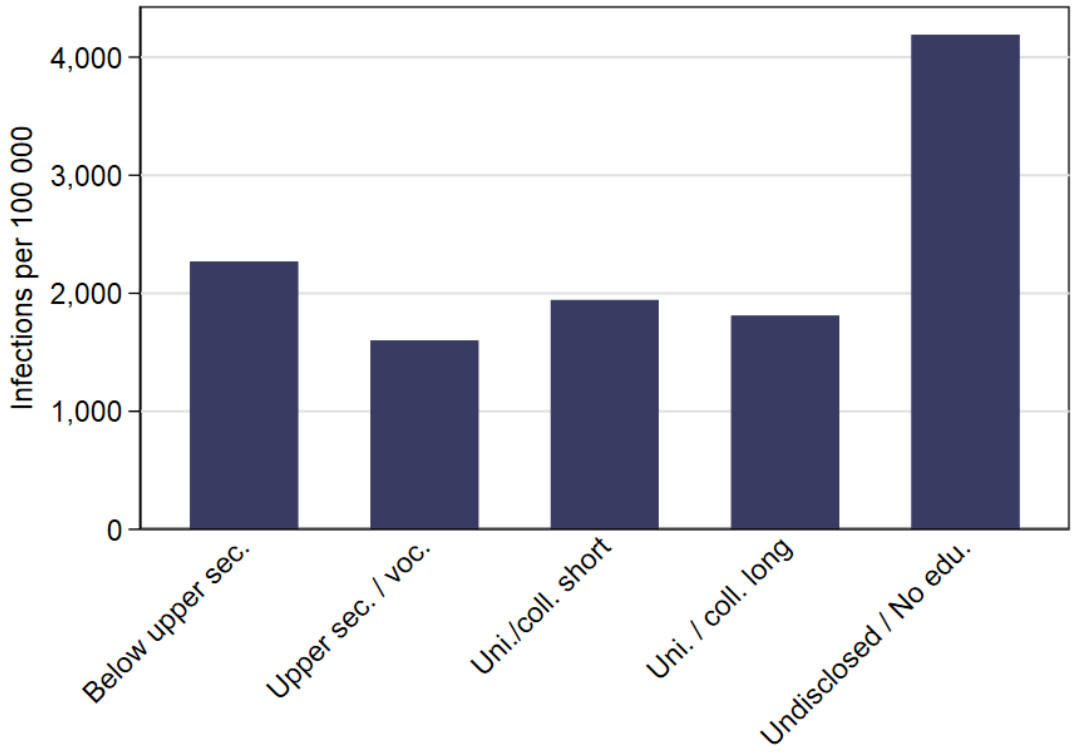


Figure 5. Confirmed cases per 100 000 over time, by education

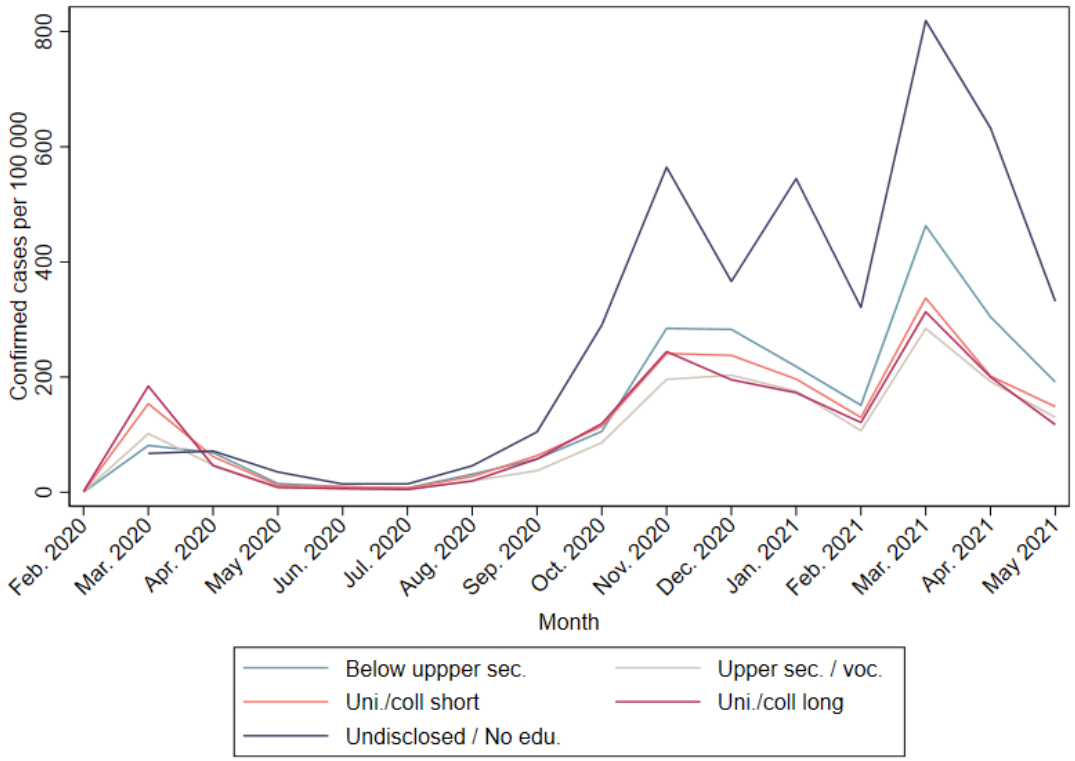


Figure 6. Confirmed cases per 100 000 by household income.
Period 02.2020 – 05.2021.

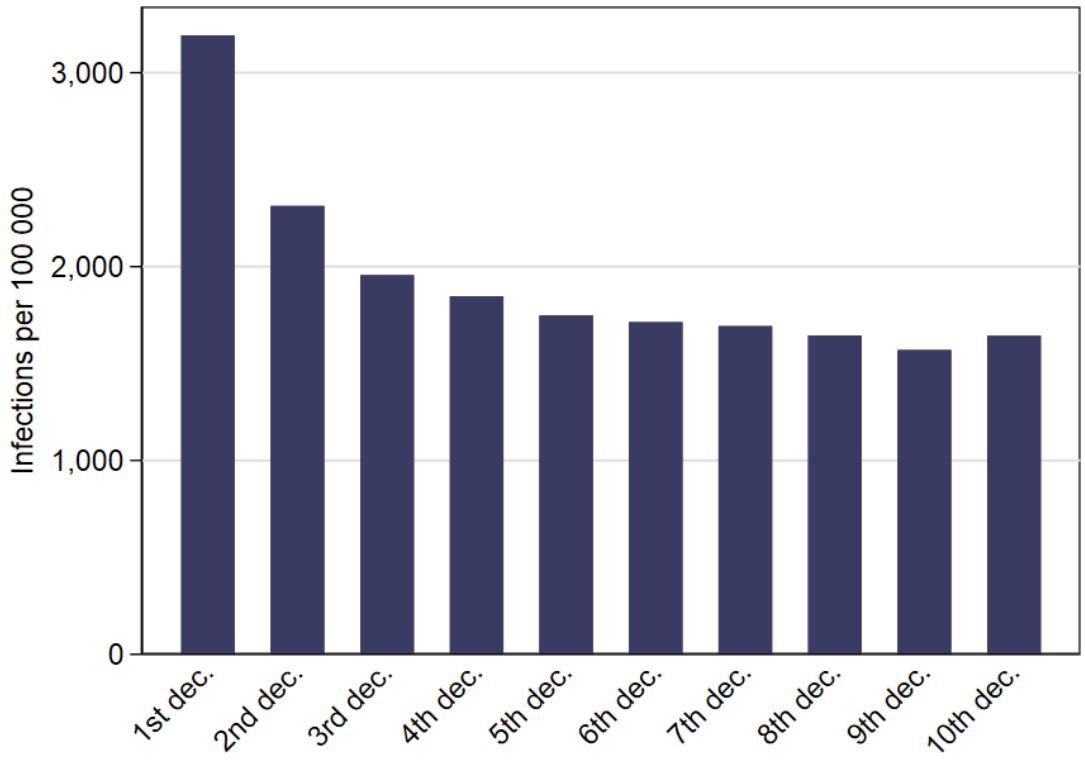


Figure 7. Confirmed cases per 100 000 over time, by household income

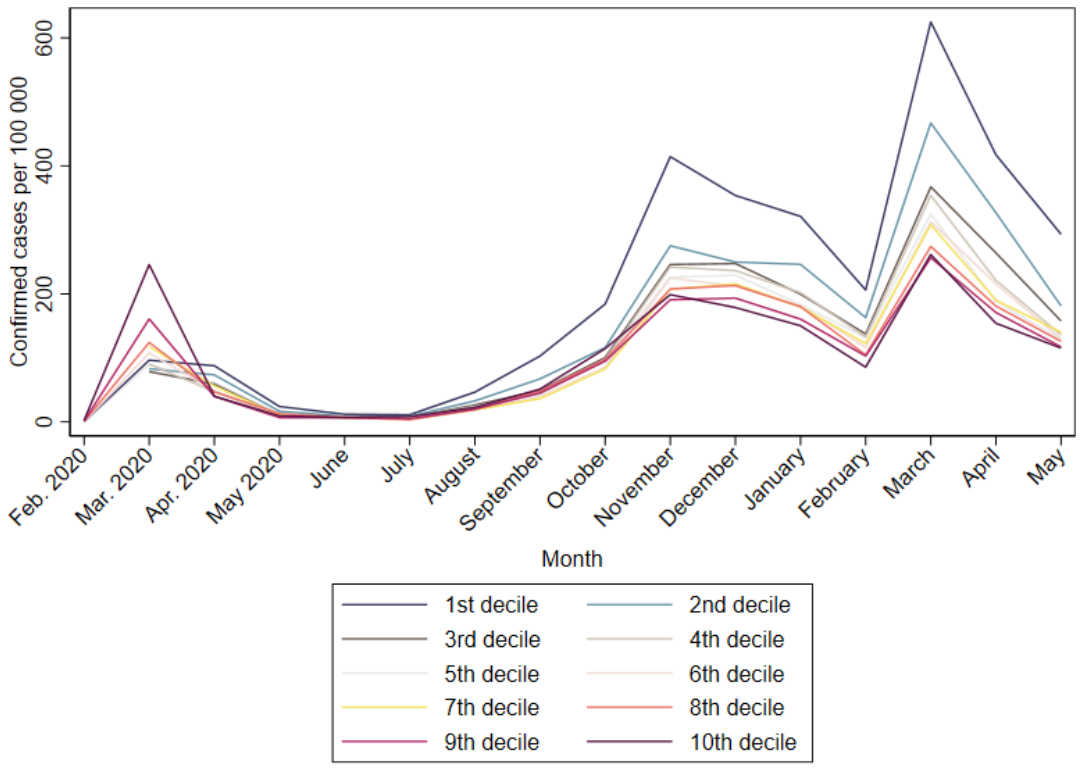
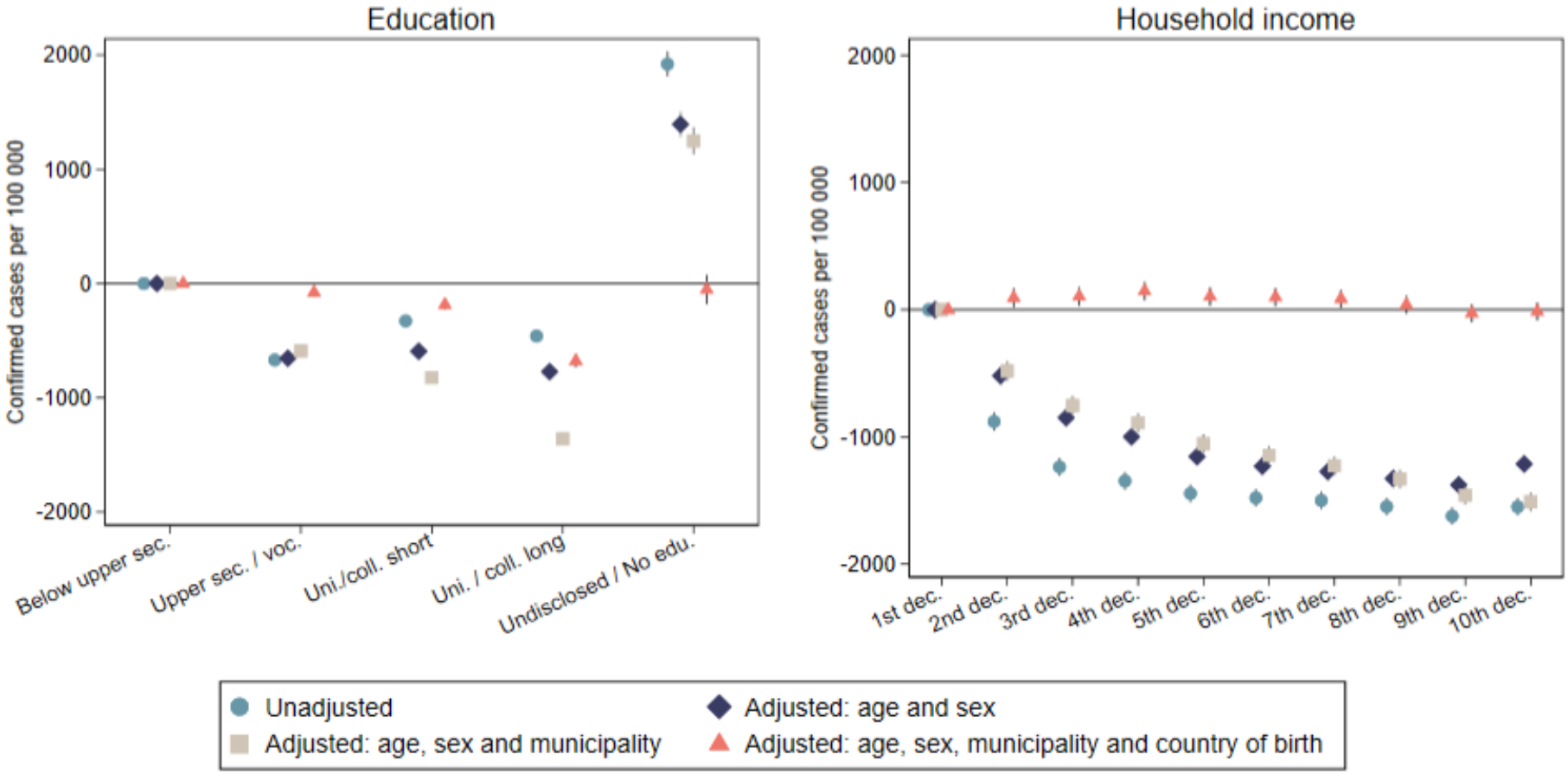


Figure 8. Confirmed cases per 100 000 by education and household income category, adjusted for age, sex, municipality of residence and country of birth. Beta coefficients, reference group: Below upper secondary (left panel), 1st income decile (right panel). The markers represent the difference in confirmed cases per 100 000 compared to the reference group standardized to 0.



Period 02.2020 – 05.2021.

Hospitalisations, invasive ventilation and deaths by education and income

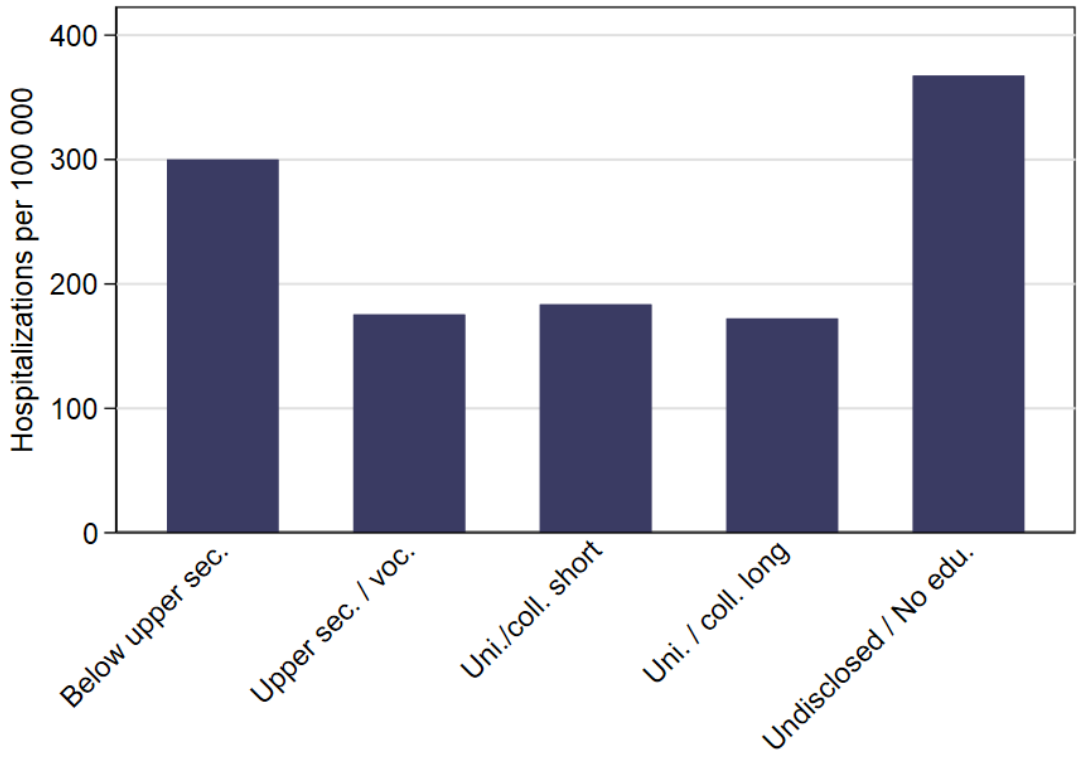
The relationship between the number of hospitalizations and education and income was roughly similar to the relationship with number of confirmed cases. The relative number of hospitalizations was higher in groups with lower education and income (Figure 9 and 11). Hospitalisations were almost twice as high among those with below upper secondary education than those with higher education levels. Hospitalisations were also much higher in the 1st and 2nd income deciles than in higher income deciles. As was observed for the number of confirmed cases, above median income the number of hospitalisations was roughly the same.

Figure 10 and 12 show the number of hospitalizations over time across different household income and education levels. The number of hospitalizations were higher among the higher income deciles and the highly educated in the first wave of the pandemic, but lower in these groups in the subsequent waves.

When adjusting for age, sex, municipality and country of birth, the differences between the reference group (below secondary education) and the other educational attainment, and between different household income levels were reduced (Figure 13). Adjustment for country of birth resulted in the undisclosed/no education group having a lower relative rate of hospitalizations compared to the reference group. Conversely, adjusting for country of birth resulted in the 2nd income decile having a slightly higher hospitalization rate.

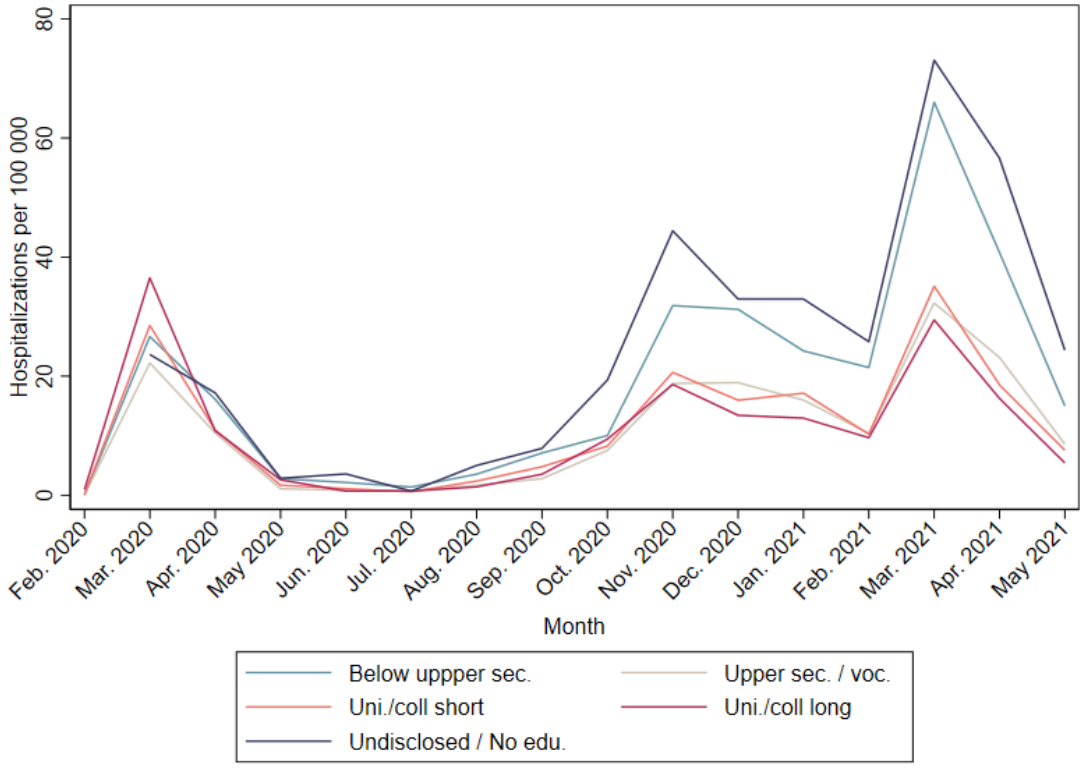
With regard to the relative number of invasive ventilation and deaths, the rate of invasive ventilation has been highest in the undisclosed/no education group and in the 1st income decile, while the number deaths have been highest in the below upper secondary category and in the 2nd income decile (Figure 14 and 15). The higher rate of invasive ventilation in the undisclosed/no education group and in the 1st income decile is probably linked to the high number of hospitalizations in these groups.

Figure 9. Hospitalizations per 100 000 by education category.
Period 02.2020 – 05.2021.



Figure

Figure 10. Hospitalizations per 100 000 over time, by education category.



Hospitalizations per 100 000 by household income category.
Period 02.2020 – 05.2021.

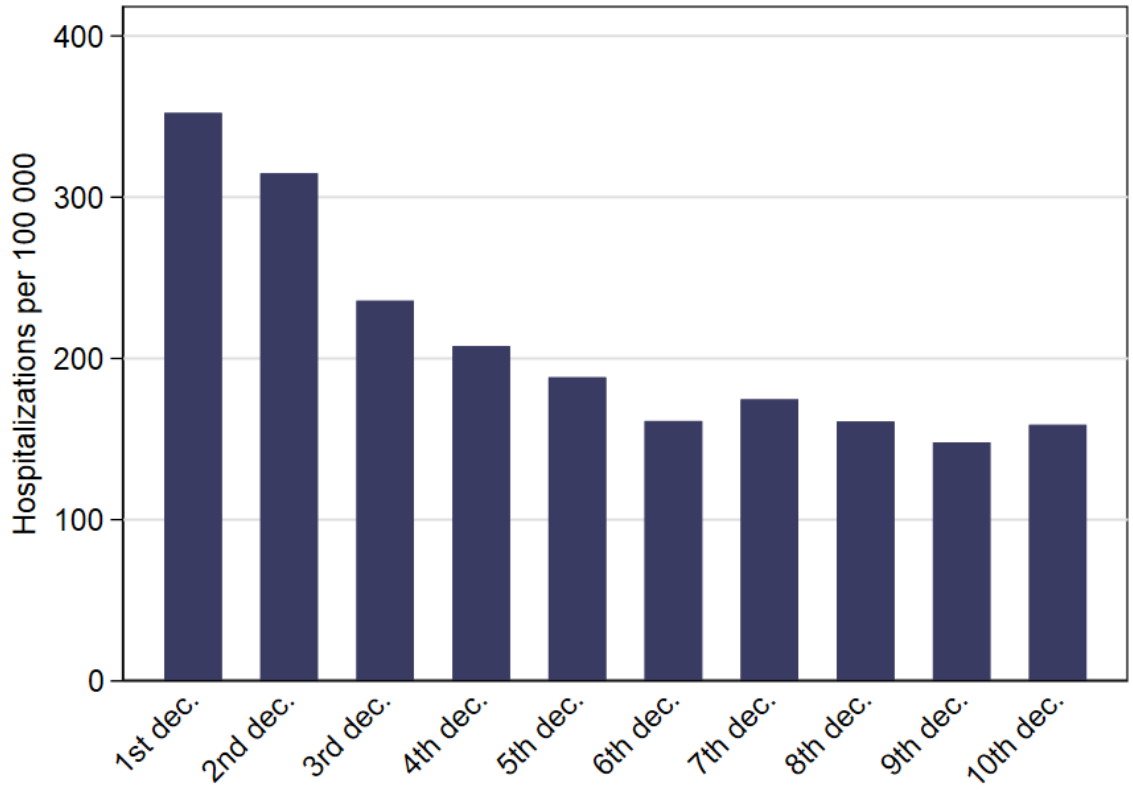


Figure 12. Hospitalizations per 100 000 over time, by household income category.

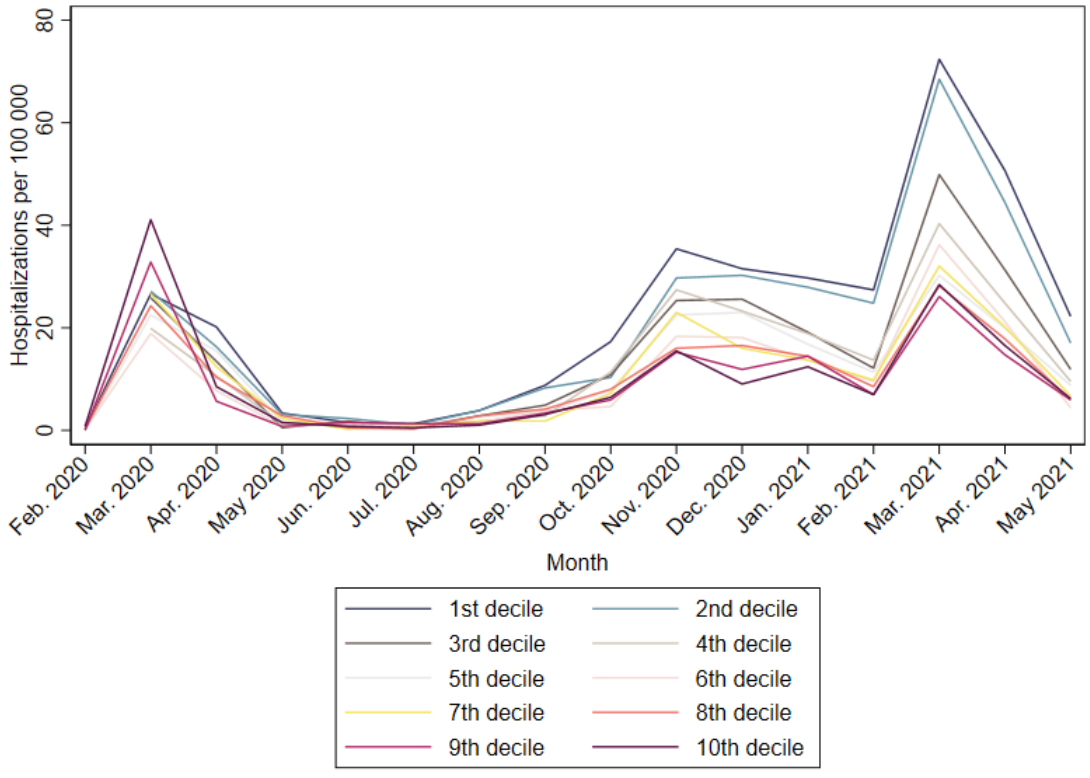
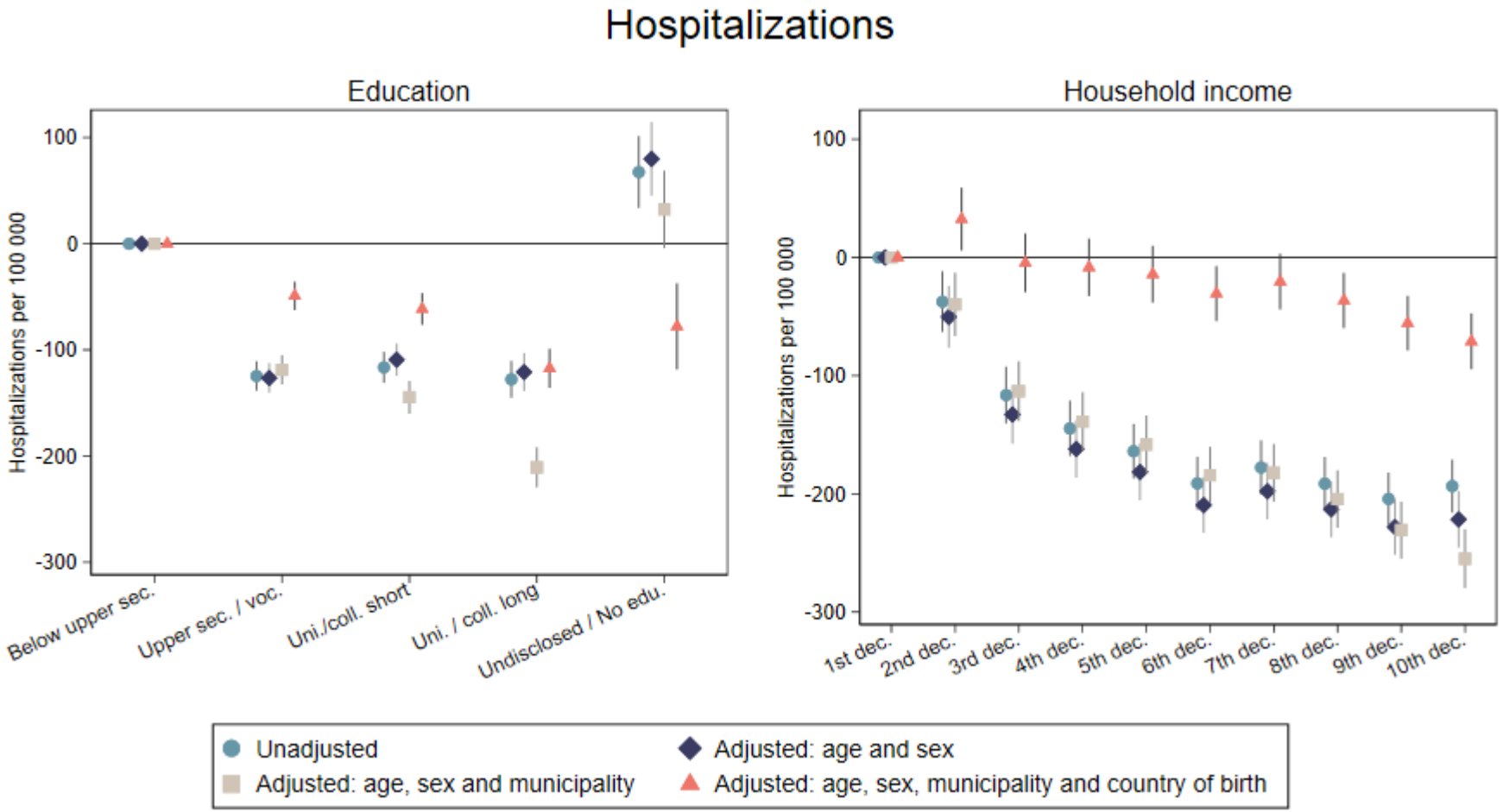


Figure 13. Hospitalizations per 100 000 by education and household income category, adjusted for age, sex, municipality of residence and country of birth. Beta coefficients, reference group: Below upper secondary (left panel), 1st income decile (right panel). The markers represent the difference in hospitalizations per 100 000 compared to the reference group standardized to 0.



Period 02.2020 – 05.2021

Figure 14. Invasive ventilation and deaths per 100 000, by education.
Period 02.2020 – 05.2021.

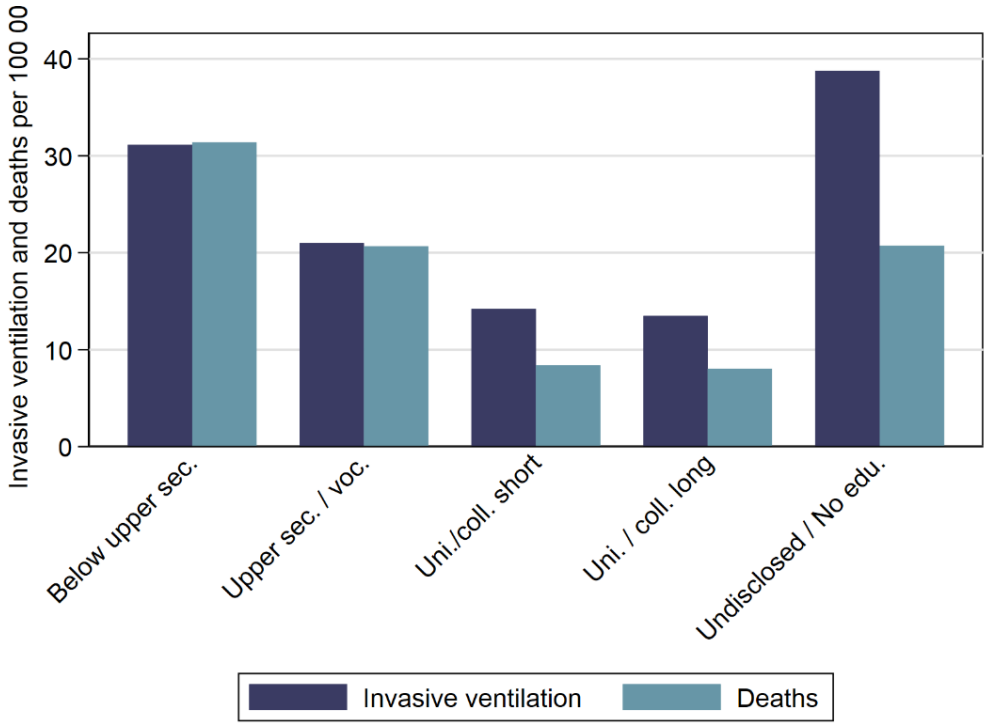
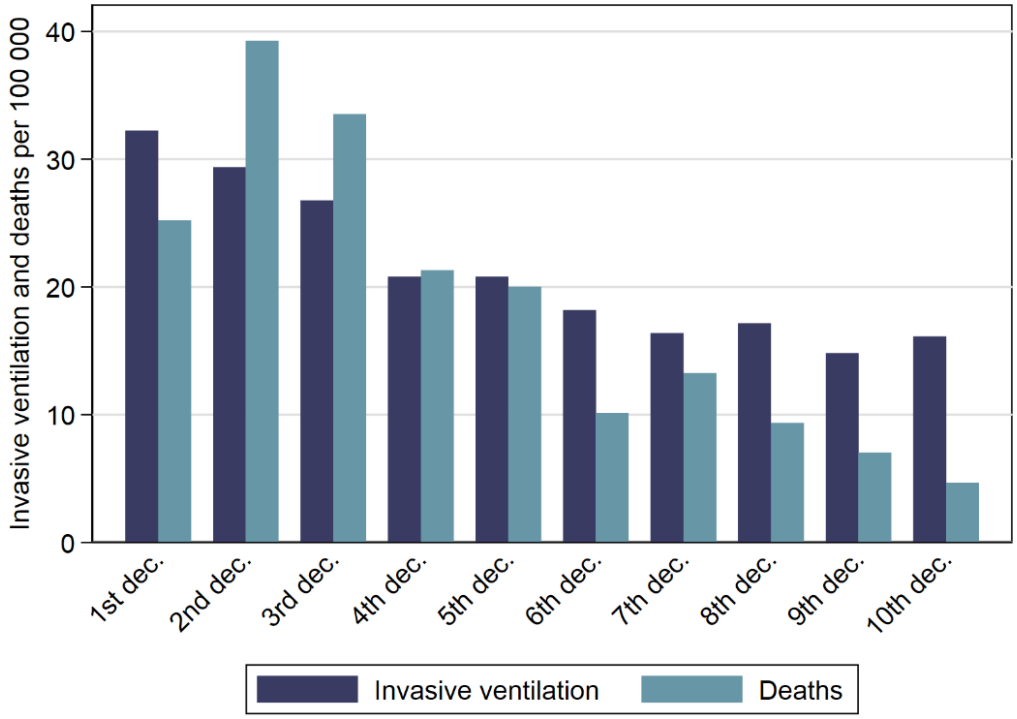


Figure 15. Invasive ventilation and deaths per 100 000, by household income.
Period 02.2020 – 05.2021.



Overall relationship between income and education and COVID-19 related outcomes

Tables 2 and 3 display the overall relationship between education and household income and COVID-19 related outcomes. As described in the above subsections, test activity, the number of confirmed cases, hospitalizations, cases of invasive ventilation and deaths differed between education and income categories, but the direction is overall clear. In general, lower education levels and lower income were associated with a lower test activity, and a higher relative number of confirmed cases, hospitalizations, cases requiring invasive ventilation, and deaths. Persons with undisclosed/no education were especially overrepresented for confirmed cases and hospitalisations. The number of confirmed cases per 100 000 was 2.3 times higher among those with undisclosed/no education (4225 per 100 000) compared to those with a university/college degree (1810 per 100 000), and twice as high in the 1st income decile (3207 per 100 000) compared to the 10th income decile (1640 per 100 000).

The difference between the highest and the lowest level of education was similar in terms of the number of hospitalizations, cases of invasive ventilation and deaths. The number of hospitalizations was 1.7 higher in the below upper secondary category (298 per 100 0000) than in the university/college, long category (173 per 100 000).

The relationship between income and the number of hospitalisations and persons requiring invasive ventilation was linear (and negative), with higher rates in the lower income deciles than in the higher income deciles. For number of deaths, the relationship with income was also linear and negative, with the exception that the number of deaths in the 1st income decile was 91, fewer deaths than in the 2nd decile (139 deaths).

Adjusted for age, sex, municipality of residence and country of birth, the difference in terms of the number of confirmed cases between persons with below upper secondary education and those with undisclosed/no education was attenuated. The adjusted numbers gave an incidence rate 10 % lower in the below upper secondary group than in the undisclosed/no education group. These two groups still had a significantly higher number of confirmed cases than persons with a university/college degree. Those with a below upper secondary degree had an almost 50 % higher number of cases than those with a long university/college degree.

Income and education are both indicators of a person's socioeconomic position but measure different aspects of this phenomenon. Appendix Table 5 shows that education and household income are related, but they do not fully overlap. Persons in the categories 'below upper secondary' and 'undisclosed/no education' are overrepresented in the lowest income deciles, while persons with a higher university or college degree are overrepresented in the highest income deciles. However, all education groups are represented in all income deciles, and hence, these variables may capture different aspects of a socioeconomic position. To investigate the interaction effect, we ran some additional models investigate the interaction between education and income for confirmed cases and hospitalizations (Appendix Figures 16a-b & 17a-b). The results from this sensitivity analyses show that there were no substantial interaction effects for confirmed cases when we adjust for age, sex, municipality and country of birth. However, in the unadjusted models and the adjusted model for hospitalizations, we found an interaction effect, especially for the persons belonging to both the lowest deciles and with education below upper secondary.

Table 2. Confirmed cases, hospitalizations, invasive ventilation and deaths by education category. Unadjusted, and for confirmed cases and hospitalizations adjusted for age, sex, municipality of residence and country of birth. Period 02.2020-05.2021

		Confirmed cases, Total (per 100 000)	**Hospitalizations, Total (per 100 000)**	**Invasive ventilation, Total (per 100 000)**	**Deaths, Total (per 100 000)**
Below upper secondary	Unadjusted	17 828 (2266.8)	2 233 (293)	230 (29.2)	229 (29.1)
	Adjusted	16 560 (2105.6)	1 992 (256)	--	--
Upper secondary/ vocational	Unadjusted	24 555 (1597.5)	2 521 (167)	306 (13.2)	292 (19.0)
	Adjusted	31 156 (2027.0)	3 138 (206)	--	--
University/college, short	Unadjusted	19 440 (1940.2)	1 796 (181)	132 (13.0)	78 (7.8)
	Adjusted	19 234 (1919.7)	1 920 (194)	--	--
University/college, long	Unadjusted	7 673 (1810.4)	713 (171)	55 (13.0)	33 (7.8)
	Adjusted	6 051 (1427.9)	576 (138)	--	--
Undisclosed/ no education	Unadjusted	5 871 (4225.5)	529 (382)	54 (38.9)	27 (19.4)
	Adjusted	2 852 (2052.7)	244 (178)	--	--

Table 3. Confirmed cases, hospitalizations, invasive ventilation and deaths by household income category. Unadjusted, and for confirmed cases and hospitalizations adjusted for age, sex, municipality of residence and country of birth. Period 02.2020-05.2021.

		Confirmed cases, total (per 100 000)	Hospitalizations, total (per 100 000)	Invasive ventilation, total (per 100 000)	Deaths, total (per 100 000)
1st decile	Unadjusted	12 393 (3207.5)	1359 (351.7)	119 (30.8)	91 (23.6)
	Adjusted	7 258 (1878.7)	866 (224.1)	--	--
2nd decile	Unadjusted	8 885 (2299.6)	1204 (311.6)	101 (26.1)	139 (36.0)
	Adjusted	7 618 (1971.9)	991 (256.6)	--	--
3rd decile	Unadjusted	7 547 (1953.3)	889 (230.1)	94 (24.3)	121 (31.3)
	Adjusted	7 660 (1982.7)	848 (219.5)	--	--
4th decile	Unadjusted	7 118 (1842.3)	797 (206.3)	80 (20.7)	77 (19.9)
	Adjusted	7 822 (2024.6)	834 (215.8)	--	--
5th decile	Unadjusted	6 738 (1744.0)	723 (187.1)	78 (20.2)	72 (18.6)
	Adjusted	7 656 (1981.5)	811 (210.0)	--	--
6th decile	Unadjusted	6 632 (1716.5)	625 (161.8)	68 (17.6)	36 (9.3)
	Adjusted	7 639 (1977.2)	747 (193.5)	--	--
7th decile	Unadjusted	6 523 (1688.3)	671 (173.7)	60 (15.5)	50 (12.9)
	Adjusted	7 588 (1964.0)	787 (203.7)	--	--
8th decile	Unadjusted	6 334 (1639.4)	619 (160.2)	61 (15.8)	31 (8.0)
	Adjusted	7 408 (1917.4)	725 (187.7)	--	--
9th decile	Unadjusted	6 067 (1570.3)	571 (147.8)	53 (13.7)	23 (6.0)
	Adjusted	7 149 (1850.2)	651 (168.5)	--	--
10th decile	Unadjusted	6 336 (1639.9)	613 (158.7)	60 (15.5)	17 (4.4)
	Adjusted	7 203 (1864.4)	592 (153.1)	--	--

Discussion

This report has shown patterns of social stratification in terms of education and income on coronavirus infection and COVID-19 disease severity. Especially persons at the lower end of the household income and education scale have experienced a higher number of cases and hospitalization. However, when adjusting for compositional differences, the differences between the groups were reduced, but trends are still apparent. Adjustments made the largest impact on confirmed cases, where differences according to income were fully attenuated, and somewhat attenuated for education. Furthermore, adjustment for country of birth generally made the largest impact on results. The group with undisclosed/no education consisted predominantly of immigrants, and adjustment for country of birth particularly attenuated the overrepresentation seen in this group.

Compared to the manyfold differences in infection rates across immigrant groups (as reported in e.g. Indseth et al. 2021), the differences in outcomes from COVID-19 between income or education groups were moderate. While the number of cases was around three times higher among foreign born compared to persons born in Norway, the number of cases among those in the 1st income decile was around double that of those in the 10th decile. Because there were relatively few deaths and persons requiring invasive ventilation, results for these outcomes may be less precise, however the general trends were consistent with the other outcomes.

In the first wave of the pandemic, persons with higher education and income were overrepresented in terms of the number of cases and hospitalizations. Infections during the early stages of the pandemic in Norway were predominantly in Norwegian residents returning from winter holidays in Italy, Austria, France and Spain (Folkehelseinstituttet 2020c). Otherwise, persons of lower socioeconomic status have persistently been overrepresented. People with lower socioeconomic status may not be able to avoid infection and severe disease to the same degree as those with more favourable socioeconomic status, probably due to multiple factors including working and living conditions. For example, having the opportunity to work from home, as is recommended to reduce infection risk, is an option more likely to be possible for people with higher income and higher qualifications. This is in line with the fundamental causes of disease theory which underlines that socioeconomic status "maintains an association with disease even when intervening mechanisms change", because socioeconomic status "embod[ies] access to important resources, [and] affect[s] multiple disease outcomes through multiple mechanisms" (Link & Phelan 1995).

In the context of the COVID-19-pandemic, socioeconomic factors such as education and income may impact on an individual's ability and opportunity to utilize services, be informed about, understand, evaluate and to follow rules and regulations to avoid exposure to the virus and further spread of infection. Disease severity, once infected, could also be affected by a person's socioeconomic status if the individual's existing health status is poorer, or if there are delays in seeking medical help.

Education

In general, lower education levels were associated with a higher relative number of confirmed cases, hospitalizations, use of invasive ventilation, and deaths. This is in line with the overall educational differences in health found outside of the COVID-19 pandemic. In a report on the health status of Norwegians in 2018, women and men with the longest education were found to live 5-6 years longer and to have better overall health than those with the shortest education (Folkehelseinstituttet 2018).

The category undisclosed/no education predominantly consisted of immigrants (93 %) and may include persons with formal education that has not been registered in Norway. Outcomes for this group should therefore be interpreted accordingly, alongside the trends seen for the other educational categories.

One explanation for the educational gradient in COVID-19 morbidity could be differences in health literacy. Health literacy describes the degree to which individuals are able to find, process, understand and apply health information in order to be able to make appropriate health-related decisions (Le et al. 2021, Mantwill et al. 2015). Both lower education and income have been found to be associated with lower levels of health literacy, and health literacy has been suggested as a mediator for health disparities (Mantwill et al. 2015). Health literacy may be related to educational differences in reading or writing skills, language comprehension, and digital competence. A survey from 2020 on health literacy in the Norwegian population found that 33% of respondents had low or weak general health literacy (Le et al. 2021). Respondents with higher than secondary school education appeared to have somewhat higher general health literacy.

In the context of the COVID-19 pandemic, health literacy may be related to an individual's understanding of the pandemic itself, how a virus spreads, and the justifications behind the rules and recommendations that are made. Throughout the pandemic, information and regulations have been in constant change as new knowledge and understanding of corona virus evolves, and in response to the changing levels of infections and disease burden in the society. Although there have been efforts to communicate current knowledge and disease situation in a way that the general population can understand, the constant changing in rules and regulations represents a challenge for everyone, including highly educated individuals. Being able to identify and access trustworthy information at the correct level and to comprehend and assess the information in relation to the current circumstances requires a certain level of competence. Experience from previous health campaigns shows that the messages that lead to positive changes in health behavior first and foremost reach the more advantaged residents. Such patterns are often reinforced in crisis situations - such as during a pandemic - where the flow of information is particularly rapid and is constantly evolving (Savoia et al. 2013, Lin et al. 2014). Studies performed during the COVID-19 pandemic indicate that health literacy is associated with individuals' knowledge of the disease, risk perception, and behavioral change due to the pandemic (Wolf et al. 2020, McCaffery et al, 2020).

Findings from Sweden also reflect a trend between educational attainment and COVID-19 outcomes, with the most studied outcome being COVID-19 associated deaths (Drefahl et al. 2020, Bartelink et al. 2020). Drefahl et al. found that people with only primary or secondary education had higher mortality than those with post-secondary education (Drefahl et al. 2020). In Stockholm, during the first-wave until 30th June 2020, there was a clear trend between increasing education and decreasing number of deaths. Individuals with post-college education had the lowest death rate compared to other groups, and these differences held after adjusting for age, sex, country of birth and living area (Bartelink et al. 2020). We do not present adjusted analyses for the outcome COVID-19-related deaths due to the small absolute number of deaths in Norway, however we do see a similar picture for hospitalizations, where individuals with University or College education longer than 4 years have the lowest rates of hospitalization even after adjusting for age, sex, municipality of residence and country of birth.

There are data limitations that affect how we can interpret our findings in relation to educational attainment. In this study we measure educational attainment according to formally registered education. We therefore do not capture or account for informal learning and educational attainment that is not formally registered, nor the difference in quality of education. Our data on education is from 2019. We limit the study population to persons 25 years and older so that it is more likely that

they would have attained their highest education level, bearing in mind that the 25 year olds in 2021 will be registered with their highest attained education at 23 years old in 2019. Particularly for the youngest in the sample, we will sometimes not have captured the highest attained education for all persons included in the study. As morbidity is low in this age group, we consider it unlikely to have large bearing on our results. A more important limitation is that the measurement error for educational attainment likely is larger among immigrants. Immigrants were much more likely to have undisclosed or no education registered; 93 % of this group did not have Norwegian background. There will be large heterogeneity within the 'undisclosed/no education'-category. Some may have formal education from their home country that has not been registered in Norway, others will be illiterate due to lack of basic education. As mentioned previously, this makes interpreting outcomes for the undisclosed/no education group a challenge.

Adjusting for age, sex, municipality of residence and country of birth

When we adjust for age, sex, municipality of residence and country of birth, the differences between groups in terms of education are in general attenuated. The differences in terms of testing rates and rates of confirmed cases between persons with below upper secondary and with undisclosed/no education were attenuated. However, these two groups still had a lower testing rate, and higher rate of confirmed cases than persons with a university/college degree.

The category undisclosed/no education mostly consisted of recently arrived immigrants, and as such unadjusted rates for this category appear as outliers in many ways. Furthermore, adjustment for country of birth had the largest effect on estimates for this category. For example, the number of confirmed cases per 100 000 was 2.3 times higher among those with undisclosed/no education compared to those with university/college education. Persons with undisclosed/no education also had higher rates for hospitalization and invasive ventilation. For hospitalizations, adjusting country of birth in addition to age, sex and municipality of residence resulted in the group undisclosed/no education having a lower rate than persons with below secondary school education, and a similar rate to university or college education.

The major risk factors for developing serious illness due to COVID-19, for example being hospitalized, is older age and underlying disease (Himmels et al. 2020). Older persons are more likely to have one or more pre-existing underlying diseases (Folkehelseinstituttet 2018). The higher number of deaths in the below upper secondary category, may be related to a higher average age in these groups, signifying that a higher share of them are elderly. Medical risk factors related to a more severe course of COVID-19 are likely to be unequally distributed by socioeconomic status. In our data we find that there is a negative trend of the proportion belonging to at least one medical risk group for severe COVID-19 with increasing educational attainment (Appendix Table 6a); a higher proportion of persons with low education belonged to at least one medical risk group compared to those with higher education. The group undisclosed/no education had the lowest proportion belonging to a medical risk group, probably due to this group's substantially lower mean age. The different proportions belonging to a medical risk group may also contribute to the overrepresentation in more severe disease among persons with below upper secondary education. We do not adjust for differences in medical risk in our models because this likely acts as a mediator in the inequalities in COVID-19 related outcomes we observe and we are interested in the total association with education, i.e. both the direct and indirect effects. For the outcome hospitalization, we have additionally adjusted for medical risk (Appendix Figure 18a). The results of this analysis suggest that after adjusting for age, sex, municipality of residence and country of birth, only a small amount of the excess hospitalizations among persons with lower education are mediated through differences in pre-existing underlying medical risk, but that lower education in itself still poses an additional risk for more serious COVID-19 that requires hospitalization.

Household income

Lower household income was associated with a lower testing rate and a higher number of cases and hospitalizations. The number of cases was twice as high in the 1st household income decile compared to the 10th household income decile. The relationship between household income and the number of cases and hospitalizations was steeper for lower levels of household income, signifying that household income has a threshold effect on COVID-19 related outcomes (Arcaya et al. 2015). When household income is above the median (5th and 6th income decile), the differences in the number of cases and hospitalizations are small. These findings align with previous research on social inequalities in health in Norway (Dahl et al. 2014; Folkehelseinstituttet 2016). Health outcomes tend to improve with every step on the socioeconomic ladder.

Lower household income might influence the incentives to follow the infection control measures but persons with a low household income could also be more vulnerable to infection through their work and occupation. High skilled workers were significantly more likely to telework when the COVID-19 pandemic hit (Espinoza & Reznikova 2020). Similarly, an Italian case study showed that number of new certified cases of coronavirus in one day was directly related to the number of trips made several days before (Cartenì & Martino 2020). Persons of a lower income may be more prone to work in occupations where teleworking is not feasible. Commute to and from work may put persons of low household income in a higher risk of contracting the disease.

On the other hand, the potential loss of income from staying home from work may result in people with low income having incentives to refrain from being tested when they have symptoms (Skogheim et al 2020). Furthermore, people with lower income may be more likely to have casual work contracts with fewer rights such as sick benefits. A low testing rate can result in a higher number of undetected cases and a faster spread of the disease in families and areas with a low median household income.

Access to health services and healthy living environments may be directly impacted by income. In the Norwegian-context, universal healthcare should reduce income effects on access to health care. While consultation fees and testing are free in relation to COVID-19, it is possible that it is still not widely known, so that perceived financial barriers may still factor in as a barrier to testing and/or seeking medical assistance. On the other hand, the relative financial consequences of fines for breaches of infection control rules, such as breaching quarantine, will also be significantly greater for people in lower income groups.

Our study uses income measured at household level. The data is from 2018 and will thus not necessarily reflect the households' financial position at the time of the pandemic. Likewise, the measure might not capture individual economic positions that differs from that of the household. Furthermore, we have used an objective measure of income, and not a subjective measure, which means that we will not capture a person's perceived position relative to others.

This study only assesses income, not other sources of wealth. Underlying differences in wealth can yield different incentive structures. Two households with same level can be in very different economic situation due to circumstances like inheritance, economic obligations outside of the household etc. Housing wealth is likely to be of particular importance here as the size of your house and garden matters for whether you can socialize according to distancing rules, and whether it is possible to isolate household members within the house in contagion occurs.

Adjusting for age, sex, municipality of residence and country of birth

Adjusting for age, sex, municipality of residence and country of birth changes the relationship between income and testing slightly. Before adjustment, the second and third income decile was slightly underrepresented. After adjustment, the relationship is more linear. Higher income levels displayed higher levels of testing even when adjusting for age, sex, municipality and country of birth.

Adjusting for age, sex, municipality of residence and country of birth lessens the association of household income and the number of cases and hospitalizations. Only a small difference between household income levels persists. Especially for confirmed cases, differences are fully attenuated and in the fully adjusted model, the middle-income deciles have the highest number of cases.

For hospitalizations, the first and second income remain slightly overrepresented. In Appendix Table 6b we observe that the first income decile has the lowest share of persons in a medical risk group. As for education, only a small amount of the excess hospitalizations by income appear to be mediated through differences in pre-existing underlying medical risk (Appendix Figure 18b).

In general, adjusting for country of birth makes the biggest difference. The 1st income decile is actually underrepresented in terms of the number of cases and hospitalizations in the full model, which likely due to the high proportion immigrants in that decile. In general, many of the assumptions on potential mechanisms drawn under the heading for education are also relevant here.

Implications, limitations and need for future research

Knowledge about burden of disease in different social groups is necessary for the authorities' mitigating strategies during the COVID-19 pandemic. It is important not only for the groups concerned, but for the overall strategy and mitigation actions to reduce infection rates and maintaining sufficient access to health services for the entire population. Furthermore, it is also important to identify which groups who have been hit hardest by the pandemic in order to prepare for the time after the pandemic, and also to improve our understanding of how socioeconomic factures influence health outcomes.

In this report we study two of the most common measures of SEP; education and income. We find that adjusting for age, sex, municipality of residence and country of birth account for some of the differences. Especially country of birth had a large impact. Our analyses do not to any large degree explore underlying reasons, mediators or mechanisms behind the disparities we observe. We do not include employment, occupational group or other individual-level measures of socioeconomic status such as household crowding or housing type, which may play an important role in the spread of COVID-19 and disease-severity and have been or will be the subject of future analyses. We do not include neighbourhood-level indicators in our analyses, only adjusting for municipality of residence. In the context of infectious-diseases such as COVID-19, municipality can give an indication of the level of infection an individual is exposed to. The limitations of analysing formally registered administrative data have already been mentioned, and the data used may not adequately or accurately capture the full effects of differences in education and household income. Furthermore, a large proportion of immigrants had missing or undeclared data for education, making interpretation for this category challenging.

There is evidence that COVID-19, as with other viral illnesses, can give persisting health problems after the acute infection (Himmels et al. 2021). Studies suggest that patients with more severe COVID-19 require more healthcare services and are more affected by adverse effects over time (Himmels et al. 2021, Skyrud et al. 2021). This can result in increased use of health services or may require use of rehabilitation services. Knowledge about how different groups have been affected by

acute COVID-19 can also help in the planning of health care provision, and to develop or adapt appropriate communication and information strategies to reach the relevant groups. The NIPH is in the process of studying in more detail the long-term health needs and health services use of people who have had acute COVID-19 infection.

It is also important to have more knowledge about how the disease spreads in different social environments and how chains of infection can be broken in, for example, densely populated areas or within households or families. Further analyses of infection tracking data and investigations of the number of close contacts and the connection between the first detected case of infection (index) and close contacts, as well as subsequent secondary infection, are necessary before we can say anything certain about this (Telle et al. 2021). We are therefore working on several analyses of infection within different types of households and families.

The results from this report may have implications for future handling of epidemics. It is likely that persons with low SEP will also be overrepresented in new epidemics. Therefore, recourses on contact tracing and other measures against spread of infection should be prioritised in areas with many persons with low SEP to better handle future epidemics.

Conclusion

Individuals with lower socioeconomic positions, as measured by educational attainment and household income, have had higher rates of confirmed infection and higher COVID-19 disease severity with higher rates of hospitalization, use of invasive ventilation and deaths. There were relatively few deaths and persons requiring invasive ventilation, however, the general trends for these outcomes are consistent with the other outcomes.

Especially those at the lower end of the household income and education scale have experienced a higher infection and hospitalization rate. When we adjust for age, sex, municipality of residence and country of birth, differences between the groups are reduced, but trends largely remain. Adjustments made the largest impact on confirmed cases, where differences according to income were fully attenuated, and somewhat attenuated for education. Furthermore, adjustment for country of birth generally made the largest impact on results. The group with undisclosed/no education consisted predominantly of immigrants, and adjustment for country of birth particularly attenuated the overrepresentation seen in this group.

Going forward, it will be important to obtain more knowledge about mechanisms behind the overrepresentation, including unravelling in more detail individual-level factors such as household type and composition, and also system-level factors such as lacking or delayed access to health services. Studies on which measures are effective at mitigating the effects of low SEP on the spread of communicable diseases are also needed.

References

Abedi V, Olulana O, Avula V, Chaudhary D, Khan A, Shahjouei S et al. Racial, Economic, and Health Inequality and COVID-19 Infection in the United States. J Racial Ethn Health Disparities. 2021;8(3):732-42.

Arcaya MC, Arcaya AL, Subramanian SV. Inequalities in health: definitions, concepts, and theories. Glob Health Action; 8. Epub ahead of print 24 June 2015. DOI: 10.3402/gha.v8.27106.

Bartelink V, Tynelius P, Walander A, Burström B, Ponce de Leon A, Nederby Öhd J, Hergens MP, Lager A. Socioekonomiska faktorer och covid-19 i Stockholms län. November 2020. Stockholm: Centrum för epidemiologi och samhällsmedicin, Region Stockholm; 2020. Rapport 2020:10.

Calderón-Larrañaga A, Vetrano DL, Rizzuto D, Bellander T, Fratiglioni L, Dekhtyar S. High excess mortality in areas with young and socially vulnerable populations during the COVID-19 outbreak in Stockholm Region, Sweden. BMJ Glob Health. 2020;5(10).

Cartenì A, Di Francesco L, Martino M. How mobility habits influenced the spread of the COVID-19 pandemic: Results from the Italian case study. Science of The Total Environment 2020; 741: 140489.

Dahl E, Bergsli H, van der Wel KA. Sosial ulikhet i helse: en norsk kunnskapsoversikt. Oslo: Høgskolen i Oslo og Akershus, Fakultet for sammfunnsfag; 2014.

Dalstra JA, Kunst AE, Borrell C, Breeze E, Cambois E, Costa G, et al. Socioeconomic differences in the prevalence of common chronic diseases: an overview of eight European countries. Int J Epidemiol 2005;34(2):316-26.

Drefahl S, Wallace M, Mussino E, Aradhya S, Kolk M, Brandén M, et al. A population-based cohort study of socio-demographic risk factors for COVID-19 deaths in Sweden. Nat Commun. 2020;11(1):5097-.

Espinoza R, Reznikova L. Who can log in? The importance of skills for the feasibility of teleworking arrangements across OECD countries. 2020.

Eurostat. Glossary: Equivalised income [web page]. [Updated 2021; read August 5th 2021] Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Equivalised_income

Folkehelseinstituttet 2016. Social inequalities in health. Norwegian Institute of Public Health, https://www.fhi.no/en/op/hin/groups/social-inequalities/ (accessed 1 July 2021).

Folkehelseinstituttet 2018. Helsetilstanden i Norge 2018. [Public Health in Norway 2018] Rapport 2018. Oslo: Folkehelseinstituttet; 2018.

Folkehelseinstituttet 2020a. Covid-19-epidemien: Kunnskap, situasjon, prognose, risiko og respons i Norge etter uke 45. Rapport 5. november 2020. Oslo: Folkehelseinstituttet; 2020.

Folkehelseinstituttet 2020b. Folkehelseinstituttets foreløpige anbefalinger om vaksinasjon mot covid-19 og om prioritering av covid-19-vaksiner, versjon 2 [The Norwegian Institute of Public Health's preliminary recommendations on vaccination against COVID-19 and on prioritization of COVID-19 vaccines, version 2]. Oslo: Folkehelseinstituttet; 2020.

Folkehelseinstituttet 2020c. COVID-19 Ukerapport: 11 2020. 18.03.2020.

Folkehelseinstituttet 2021a. COVID-19 Ukerapport: uke 21. 02.06.2021.

Folkehelseinstituttet 2021b. COVID-19 Ukerapport: uke 30. 04.08.2021.

Gallo V, Mackenbach JP, Ezzati M, Menvielle G, Kunst AE, Rohrmann S, et al. Social inequalities and mortality in Europe—results from a large multi-national cohort. PLoS One 2012;7(7):e39013.

Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 1). J Epidemiol Community Health. 2006;60(1):7-12.

Himmels JPW, Borge TC, Brurberg KG, Gravningen KM, Feruglio SL, Berild JD (2020). COVID-19: COVID-19 and risk factors for hospital admission, severe disease and death [Covid-19 og risikofaktorer for sykehusinnleggelse, alvorlig sykdom og død - en hurtigo-versikt, tredje oppdatering. Hurtigoversikt 2020]. Oslo: Norwegian Institute of Public Health; 2020.

Himmels JPW, Gomez Castaneda M, Brurberg KG, Gravningen KM. COVID-19: Long-Term Symptoms after COVID-19 [Langvarige symptomer etter covid-19. Hurtigoversikt 2021] Oslo: Norwegian Institute of Public Health, 2021.

Indseth T, Elgersma IH, Strand BH, Telle K, Labberton AS, Arnesen T, et al. Covid-19 blant personer født utenfor Norge, justert for yrke, trangboddhet, medisinsk risikogruppe, utdanning og inntekt, Rapport 2021 [COVID-19 among persons born outside Norway, adjusted for occupation, household crowding, medical risk group, education and income, Report 2021]. Oslo: Norwegian Institute of Public Health; 2021.

Kivimaki M, Batty GD, Pentti J, Shipley MJ, Sipila PN, Nyberg ST, et al. Association between socioeconomic status and the development of mental and physical health conditions in adulthood: a multi-cohort study. Lancet Public Health 2020;5(3):e140-e9.

Kjøllesdal M, Magnusson K. Occupational risk of COVID-19 by country of birth. A register-based study. MedRxiv [In press]. 2021.

Le C, Finbråten H, Pettersen K, Guttersrud Ø. Befolkningens helsekompetanse, del I. The International Health Literacy Population Survey 2019–2021 (HLS19) – et samarbeidsprosjekt med nettverket M-POHL tilknyttet WHO-EHII. Rapport IS-2959. 2021.

Li SL, Pereira RHM, Prete CA, Jr., Zarebski AE, Emanuel L, Alves PJH, et al. Higher risk of death from COVID-19 in low-income and non-White populations of São Paulo, Brazil. BMJ Glob Health. 2021;6(4).

Lin L, Jung M, McCloud RF, Viswanath K. Media Use and Communication Inequalities in a Public Health Emergency: A Case Study of 2009–2010 Pandemic Influenza a Virus Subtype H1N1. Public Health Reports. 2014;129(6_suppl4):49-60.

Link BG, Phelan J. Social Conditions As Fundamental Causes of Disease. J Health Soc Behav. 1995;35:80-94.

Mackenbach JP, Kulhanova I, Artnik B, Bopp M, Borrell C, Clemens T, et al. Changes in mortality inequalities over two decades: register based study of European countries. BMJ 2016;353:i1732.

Magnusson K, Nygård K, Methi F, Vold L, Telle K. Occupational risk of COVID-19 in the 1st vs 2nd wave of infection. medRxiv. 2020:2020.10.29.20220426.

Mamelund S-E, Dimka J. Social inequalities in infectious diseases. Scandinavian Journal of Public Health. March 2021. doi:10.1177/1403494821997228

Mantwill S, Monestel-Umaña S, Schulz PJ. The Relationship between Health Literacy and Health Disparities: A Systematic Review. PLOS ONE [Internet]. PLOS ONE; 2015;10(12):e0145455.

McCaffery K, Dodd R, Cvejic E, Ayre J, Batcup C, Isautier J, et al. Disparities in COVID-19 related knowledge, attitudes, beliefs and behaviours by health literacy. medRxiv. 2020:2020.06.03.20121814.

Nystad W, Hjellvik V, Larsen IK, Ariansen I, Helland E, Johansen KI, et al. Underlying conditions in adults with COVID-19. Tidsskr Nor Laegeforen. 2020;140(13).

Phelan JC, Link BG, Tehranifar P. Social Conditions as Fundamental Causes of Health Inequalities: Theory, Evidence, and Policy Implications. J Health Soc Behav 2010; 51: S28–S40.

Public Health England. Disparities in the risk and outcomes of COVID-19. London: Public Health England; 2020 August.

Savoia E, Lin L, Viswanath K. Communications in Public Health Emergency Preparedness: A Systematic Review of the Literature. Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science. 2013;11(3):170-84.

Skogheim, Orderud, Ruud og Søholt (2021): Informasjon og tiltak rettet mot innvandrerbefolkningen i forbindelse med Covid-19: Delrapport 2, NIBR-rapport 2020:27, By- og regionforskningsinstituttet NIBR, OsloMet

Skyrud K, Telle K, Magnusson K. Impacts of COVID-19 on long-term health and health care use. medRxiv. 2021:2021.02.16.21251807.

Søegaard EGI, Kan Z. COVID-19 infections in the districts of Oslo. Tidsskr Nor Laegeforen. 2021;141(6).

Telle K, Jørgensen SB, Hart R, Greve-Isdahl M, Kacelnik O. Secondary attack rates of COVID-19 in Norwegian families: A nation-wide register-based study. medRxiv. 2021:2021.03.06.21252832.
Telle K, Jørgensen SB, Hart R, Greve-Isdahl M, Kacelnik O. Occupational risk of COVID-19 in the 1st vs 2nd wave of infection. medRxiv. 2021:2020.10.29.20220426.
Vist G, Arentz-Hansen E, Vedøy T, Spilker R, Hafstad E, Giske L. Incidence and severe outcomes from COVID-19 among immigrant and minority ethnic groups and among groups of different socio-economic status. Oslo: Norwegian Institute of Public Health; 2021.
Wolf MS, Serper M, Opsasnick L, O'Conor RM, Curtis L, Benavente JY, et al. Awareness, Attitudes, and Actions Related to COVID-19 Among Adults With Chronic Conditions at the Onset of the U.S. Outbreak: A Cross-sectional Survey. Annals of internal medicine. 2020;173(2):100-9.

Appendix

Test activity

Appendix Table 4a. Proportion tested at least once and proportion of these who have tested positive before and after 15th June 2020, by education category

	Until 15th June		After 15th June	
Highest completed education	Percent tested	Percent positive tests of all tested	Percent tested	Percent positive tests of all tested
Below upper secondary	4.7 %	5.6 %	38.9 %	5.6 %
Upper secondary/ vocational	4.5 %	5.0 %	42.0 %	3.6 %
University/ college, short	6.8 %	5.0 %	55.4 %	3.3 %
University/ college, long	6.0 %	5.2 %	56.0 %	3.0 %
Undisclosed/no education	2.2 %	1.1 %	43.5 %	9.3 %

Appendix Table 4b. Proportion tested at least once and proportion of these who have tested positive before and after 15th June, by household income category

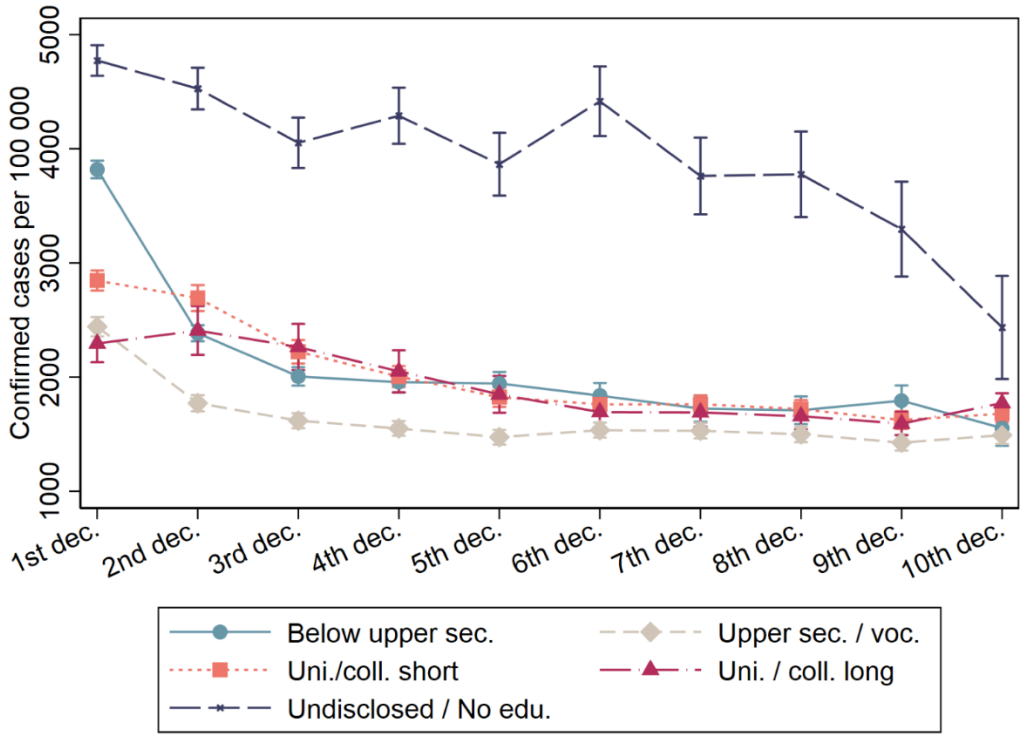
	Until 15th June		After 15th June	
Household income equivalents	Percent tested	Percent positive tests of all tested	Percent tested	Percent positive tests of all tested
1st decile	4.4 %	7.6 %	44.8 %	6.8 %
2nd decile	5.7 %	5.1 %	42.3 %	5.2 %
3rd decile	5.5 %	4.7 %	43.1 %	4.3 %
4th decile	5.4 %	4.7 %	44.6 %	3.9 %
5th decile	5.4 %	4.7 %	46.4 %	3.6 %
6th decile	5.4 %	4.7 %	48.0 %	3.4 %
7th decile	5.3 %	5.0 %	48.6 %	3.3 %
8th decile	5.2 %	4.9 %	49.1 %	3.1 %
9th decile	5.0 %	5.2 %	48.8 %	2.9 %
10th decile	5.0 %	6.6 %	47.9 %	3.0 %

Education and income

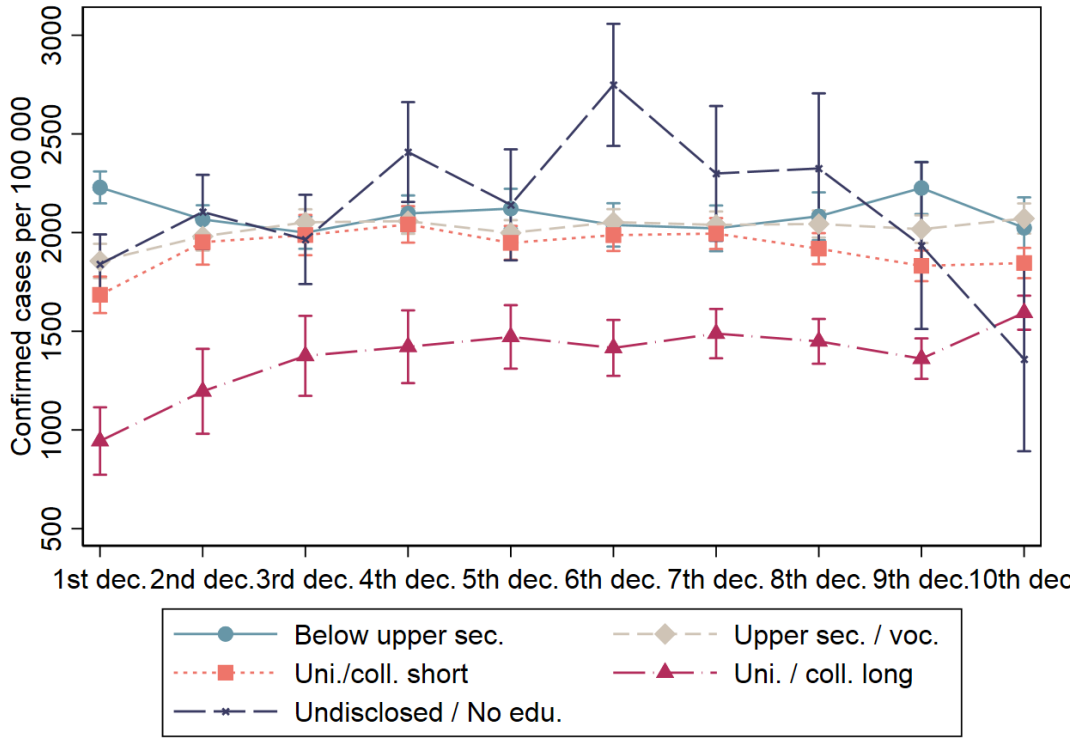
Appendix Table 5. Crosstab matrix between education and household income. Percent of each income decile belonging to each education category.

	Below upper secondary	Upper secondary/ vocational	University/ college, short	University/ college, long	Undisclosed/ no education
1st decile	32	26	24	7	11
2nd decile	38	37	15	4	6
3rd decile	29	44	18	5	4
4th decile	23	46	22	6	3
5th decile	19	46	26	7	3
6th decile	16	44	29	9	2
7th decile	14	41	31	12	2
8th decile	13	41	30	15	1
9th decile	11	39	31	18	1
10th decile	8	33	33	26	1
TOTAL	20	40	26	11	3

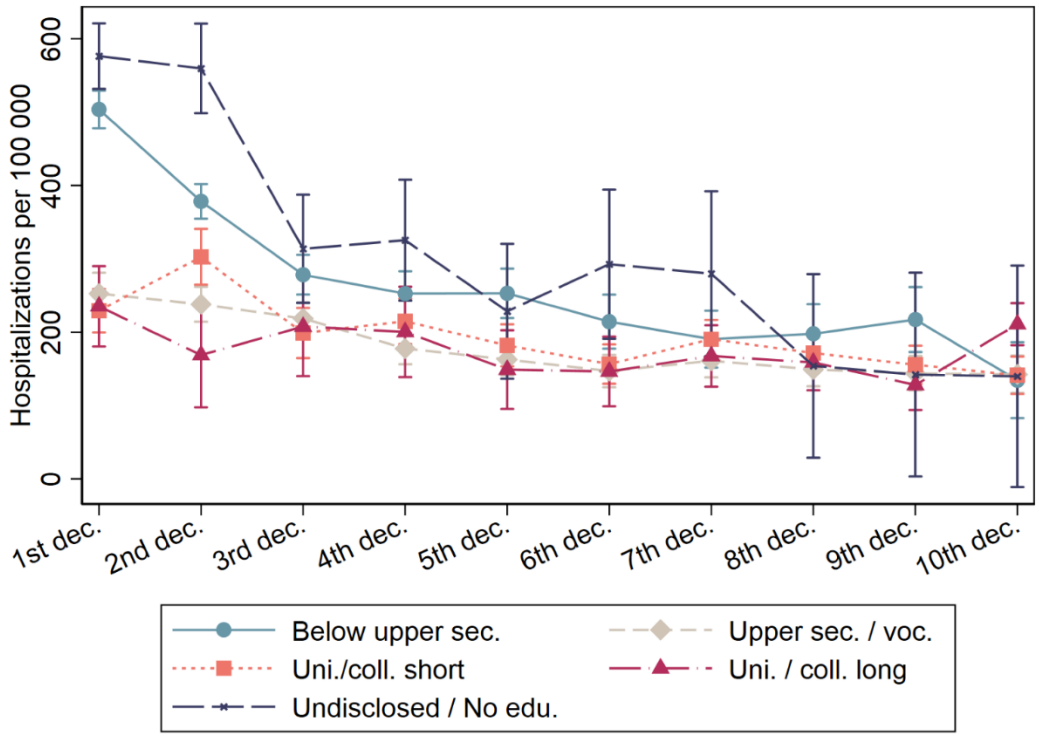
Appendix Figure 16a. Confirmed cases per 100 000: interaction effect between education and household income, unadjusted. Reference group: the 1st income decile and education below upper secondary. Period: 02.2020-05.2021.



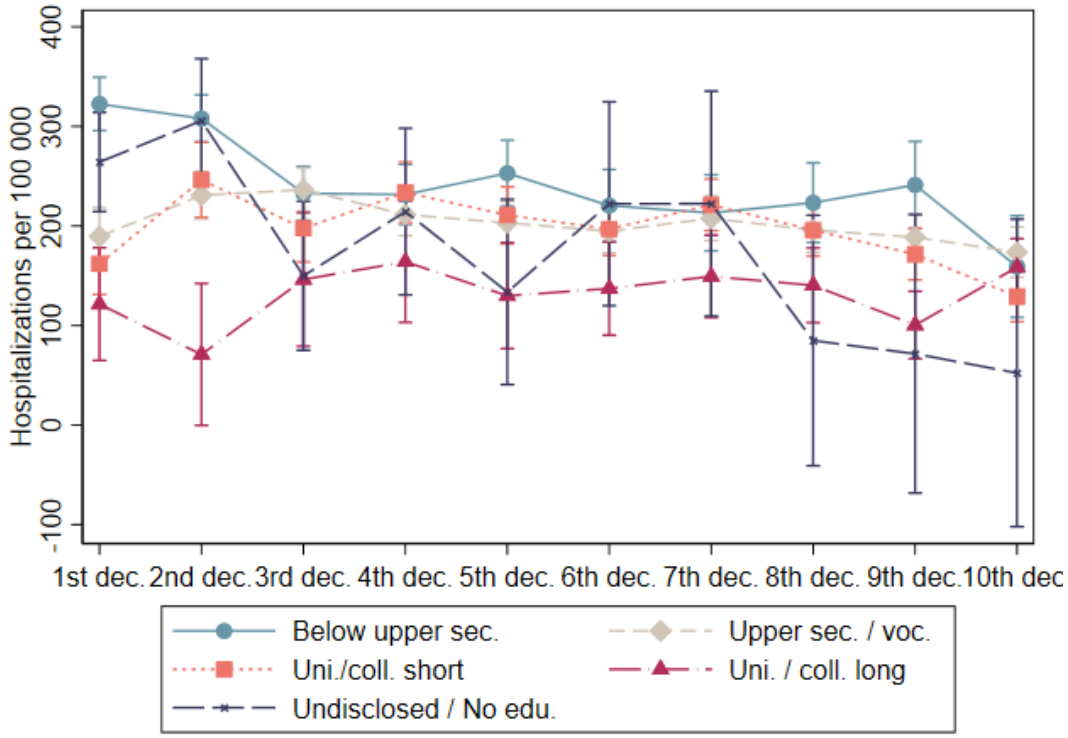
Appendix Figure 16b. Confirmed cases per 100 000: interaction effect between education and household income, adjusted for age, sex, municipality of residence and country of birth. Reference group: persons in the 1st income decile and education below upper secondary. Period: 02.2020-05.2021.



Appendix Figure 17a. Hospitalizations per 100 000: interaction effect between education and household income, unadjusted. Reference group: the 1st income decile and education below upper secondary. Period: 02.2020-05.2021.



Appendix Figure 17b. Hospitalizations per 100 000: interaction effect between education and household income, adjusted for age, sex, municipality of residence and country of birth . Reference group: the 1st income decile and education below upper secondary. Period: 02.2020-05.2021.



Medical risk groups

Medical risk groups are a set of indicator variables for underlying conditions or diseases that have been identified by the NIPH to convey higher risk of severe COVID-19 (requiring hospitalization). These risk groups are categorized as present or not. The medical risk groups are identified on the basis of diagnostic codes registered in the primary and specialist health services with a look-back period to 2017. There are 14 defined medical risk groups: organ transplantation; neurological diseases or muscle diseases that cause impaired coughing or lung function; chronic kidney disease or significant renal impairment; chronic liver disease or significant hepatic impairment; immunosuppressive therapy; diabetes; chronic lung disease (other than well-regulated asthma); obesity; haematological cancer during the last five years; other active cancer, ongoing or recently discontinued treatment for cancer; immune deficiency; chronic cardiovascular disease (with the exception of high blood pressure); stroke; dementia. See (Nystad et al. 2020) and Appendix 1 in (Folkehelseinstituttet 2020b) for further details and included diagnosis codes.

Appendix Table 6. Proportion belonging to at least one medical risk group for severe COVID-19, by a) education and b) household income category

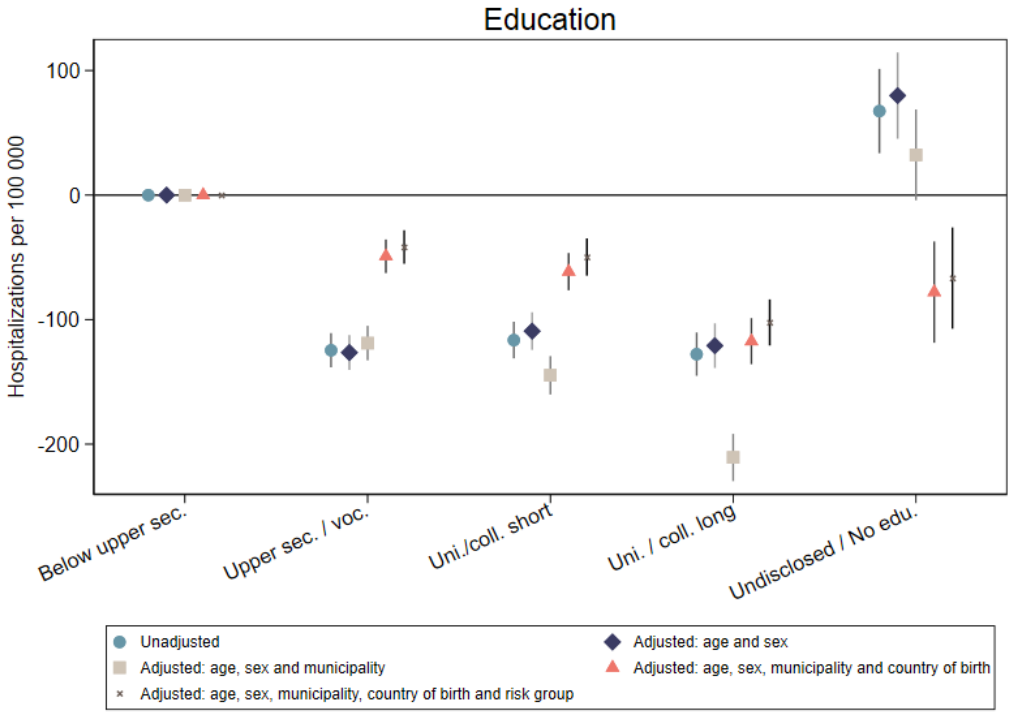
a) By education category

Highest completed education	Percent in medical risk group
Below upper secondary	30.0 %
Upper secondary/ vocational	26.4 %
University/ college, short	17.8 %
University/ college, long	14.5 %
Undisclosed/no education	9.8 %

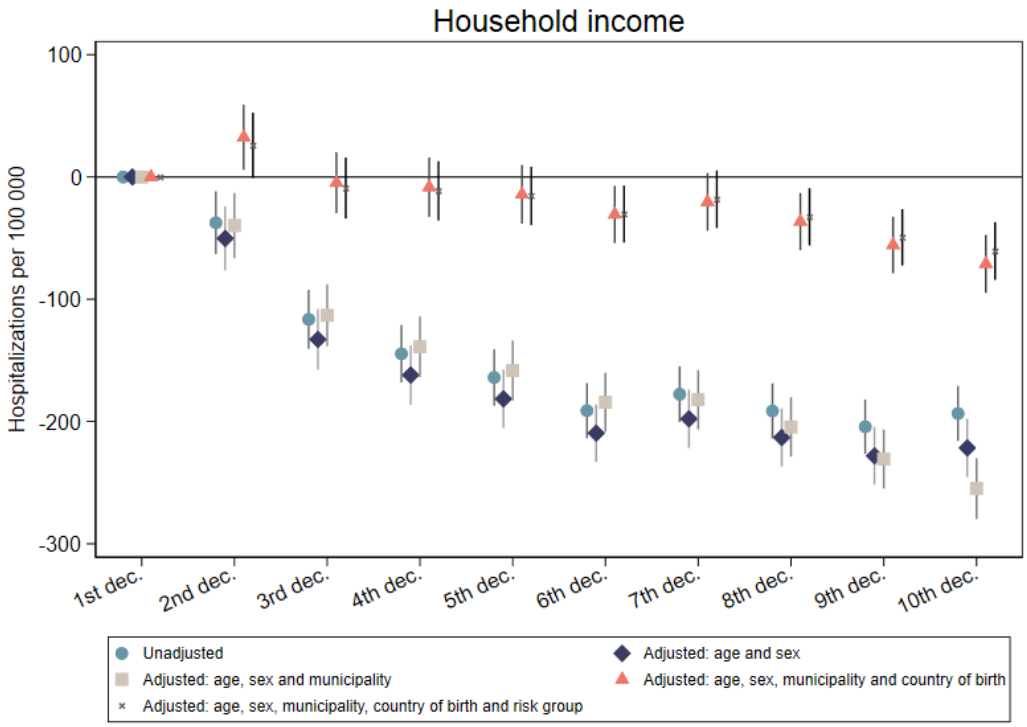
b) By household income category

Household income equivalents	Percent in medical risk group
1st decile	17.2 %
2nd decile	28.6 %
3rd decile	28.5 %
4th decile	26.9 %
5th decile	24.9 %
6th decile	23.3 %
7th decile	21.9 %
8th decile	20.9 %
9th decile	20.0 %
10th decile	19.5 %

Appendix Figure 18a. Hospitalizations per 100 000 by education category, adjusted for age, sex, municipality of residence, country of birth and medical risk group. Reference group: Below upper secondary. Period 02.2020 – 05.2021



Appendix Figure 18b. Hospitalizations per 100 000 by household income, adjusted for age, sex, municipality of residence, country of birth and medical risk group. Reference group: 1st income decile. Period 02.2020 – 05.2021



Regression coefficients

Appendix Table 7a. Regression results: Confirmed cases per 100 000 by education, adjusted for age, sex, municipality of residence and country of birth. Beta coefficients.

	Unadjusted	Adjusted for age and sex	Adjusted for age, sex and municipality	Adjusted for age, sex, municipality and country of birth
Below upper secondary	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Upper sec. / voc.	-694.359***	-675.207***	-590.309***	-76.574***
	(19.98)	(20.06)	(19.95)	(19.30)
Uni. / coll. Short	-344.608***	-609.266***	-824.626***	-182.502***
	(22.09)	(22.63)	(22.97)	(22.08)
Uni. / coll. Long	-470.855***	-780.538***	-1356.597***	-673.680***
	(26.93)	(27.62)	(28.92)	(28.18)
Undisclosed / No edu.	2151.345***	1605.486***	1181.525***	-123.709
	(58.00)	(58.66)	(58.55)	(63.76)
25-29 years		0.000	0.000	0.000
		(.)	(.)	(.)
30-34 years		-519.305***	-474.341***	-602.014***
		(39.55)	(39.33)	(39.16)
35-39 years		-527.983***	-418.087***	-729.652***
		(39.98)	(39.76)	(39.58)
40-44 years		-584.642***	-447.681***	-685.492***
		(39.90)	(39.71)	(39.50)
45-49 years		-566.880***	-408.371***	-557.843***
		(39.30)	(39.12)	(38.86)
50-54 years		-831.246***	-632.949***	-661.460***
		(38.05)	(37.88)	(37.63)
55-59 years		-1165.139***	-964.708***	-906.198***
		(37.54)	(37.35)	(37.11)
60-64 years		-1649.618***	-1414.651***	-1259.419***
		(36.39)	(36.19)	(35.95)
65-59 years		-2044.992***	-1760.022***	-1549.656***
		(34.85)	(34.63)	(34.40)
70-74 years		-2272.705***	-1993.941***	-1723.352***
		(34.16)	(33.96)	(33.72)
75-79 years		-2382.464***	-2141.492***	-1801.974***
		(34.53)	(34.35)	(34.10)
80-84 years		-2493.506***	-2228.335***	-1834.729***
		(36.97)	(36.79)	(36.54)
85-89 years		-2436.151***	-2166.986***	-1722.033***
		(42.61)	(42.44)	(42.19)
90-94 years		-2376.339***	-2138.721***	-1651.818***
		(53.61)	(53.46)	(53.23)
95-99 years		-2373.635***	-2175.371***	-1664.173***
		(86.34)	(86.13)	(85.93)
>=100		-2085.401***	-1954.463***	-1438.071***
		(254.85)	(254.10)	(254.99)
Sex		-91.222***	-91.327***	-60.608***
		(14.32)	(14.25)	(14.22)
Constant	2296.550***	3584.428***	5929.615***	4527.112***
	(17.17)	(34.33)	(45.54)	(44.16)

* p < 0.05, ** p < 0.01, *** p < 0.001. Reference group: Below upper secondary, 25-29 years and male (municipality: Oslo, country of birth: Norway). Municipalities and countries of birth not shown in this table. Standard errors in parenthesis.

Appendix Table 7b. Regression results: Hospitalizations per 100 000 by education, adjusted for age, sex, municipality of residence and country of birth. Beta coefficients.

	Unadjusted	Adjusted for age and sex	Adjusted for age, sex and municipality	Adjusted for age, sex, municipality and country of birth
Below upper secondary	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Upper sec. / voc.	-126.031***	-128.545***	-119.858***	-50.299***
	(7.03)	(7.11)	(7.11)	(6.94)
Uni. / coll. Short	-111.778***	-111.298***	-145.713***	-62.462***
	(7.53)	(7.73)	(7.93)	(7.71)
Uni. / coll. Long	-122.029***	-122.726***	-211.154***	-118.330***
	(8.91)	(9.17)	(9.75)	(9.53)
Undisclosed / No edu.	88.791***	91.721***	31.911	-78.161***
	(17.70)	(18.08)	(18.15)	(20.31)
25-29 years		0.000	0.000	0.000
		(.)	(.)	(.)
30-34 years		-16.369	-8.720	-21.859*
		(10.37)	(10.37)	(10.40)
35-39 years		-0.877	16.961	-16.986
		(10.66)	(10.67)	(10.74)
40-44 years		-0.330	22.013*	-4.353
		(10.68)	(10.74)	(10.77)
45-49 years		34.769**	61.164***	42.186***
		(10.91)	(10.95)	(10.92)
50-54 years		51.861***	83.501***	75.641***
		(11.01)	(11.08)	(11.07)
55-59 years		44.403***	75.665***	76.696***
		(11.21)	(11.29)	(11.31)
60-64 years		16.930	51.726***	64.741***
		(11.22)	(11.27)	(11.32)
65-59 years		-19.716	21.657*	40.712***
		(10.80)	(10.86)	(10.89)
70-74 years		-13.368	27.776*	53.968***
		(11.22)	(11.27)	(11.31)
75-79 years		11.038	47.792***	83.431***
		(12.45)	(12.51)	(12.56)
80-84 years		19.233	58.533***	101.322***
		(15.32)	(15.37)	(15.44)
85-89 years		14.018	52.150**	102.191***
		(18.80)	(18.82)	(18.87)
90-94 years		-10.538	21.698	77.615**
		(23.89)	(23.90)	(23.91)
95-99 years		-43.994	-18.650	40.870
		(38.03)	(38.00)	(38.02)
>=100		-218.748***	-204.072***	-147.078***
		(8.38)	(9.39)	(9.74)
Sex		-15.396**	-14.991**	-14.839**
		(4.70)	(4.70)	(4.72)
Constant	293.241***	290.937***	642.541***	458.739***
	(6.20)	(9.64)	(14.39)	(13.77)

* p < 0.05, ** p < 0.01, *** p < 0.001. Reference group: Below upper secondary, 25-29 years and male (municipality: Oslo, country of birth: Norway). Municipalities and countries of birth not shown in this table. Standard errors in parenthesis.

Appendix Table 7c. Regression results: Testing per 100 000 by education, adjusted for age, sex, municipality of residence and country of birth. Beta coefficients.

	Unadjusted	Adjusted for age and sex	Adjusted for age, sex and municipality	Adjusted for age, sex, municipality and country of birth
Below upper secondary	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Upper sec. / voc.	2979.791***	4180.948***	4247.142***	3923.439***
	(69.23)	(67.39)	(66.87)	(67.52)
Uni. / coll. Short	16734.303***	12084.924***	10711.674***	10426.596***
	(75.08)	(73.83)	(73.96)	(74.87)
Uni. / coll. Long	17455.410***	12447.310***	9345.898***	9446.159***
	(94.95)	(93.52)	(95.15)	(96.13)
Undisclosed / No edu.	7193.952***	-1979.302***	-3707.502***	-422.500**
	(145.53)	(147.13)	(146.40)	(157.45)
25-29 years		0.000	0.000	0.000
		(.)	(.)	(.)
30-34 years		-1317.007***	-1007.771***	-738.365***
		(111.57)	(110.89)	(110.69)
35-39 years		-3277.319***	-2696.873***	-2153.994***
		(113.79)	(113.14)	(113.25)
40-44 years		-6912.418***	-6203.874***	-5677.512***
		(115.54)	(114.84)	(115.07)
45-49 years		-11470.148***	-10599.232***	-10304.927***
		(114.72)	(114.10)	(114.22)
50-54 years		-16087.503***	-15006.030***	-14897.571***
		(113.85)	(113.35)	(113.44)
55-59 years		-19755.200***	-18661.721***	-18714.043***
		(116.05)	(115.58)	(115.68)
60-64 years		-23529.139***	-22320.644***	-22470.907***
		(118.69)	(118.31)	(118.39)
65-59 years		-31588.688***	-30111.573***	-30360.480***
		(118.90)	(118.59)	(118.70)
70-74 years		-36496.651***	-35007.661***	-35346.309***
		(119.53)	(119.25)	(119.39)
75-79 years		-37827.474***	-36482.324***	-36887.237***
		(125.44)	(125.09)	(125.28)
80-84 years		-37406.045***	-35996.739***	-36407.561***
		(148.92)	(148.21)	(148.41)
85-89 years		-34486.578***	-33086.437***	-33536.632***
		(184.70)	(183.22)	(183.46)
90-94 years		-30681.948***	-29414.327***	-29886.814***
		(251.63)	(248.51)	(248.67)
95-99 years		-26762.675***	-25722.330***	-26227.930***
		(447.15)	(439.15)	(439.51)
>=100		-24816.395***	-24067.708***	-24575.083***
		(1143.13)	(1125.11)	(1124.44)
Sex		5666.096***	5667.735***	5855.650***
		(49.38)	(48.97)	(49.12)
Constant	40463.302***	55889.374***	63680.411***	64224.779***
	(56.25)	(97.50)	(114.38)	(116.90)

* p < 0.05, ** p < 0.01, *** p < 0.001. Reference group: Below upper secondary, 25-29 years and male (municipality: Oslo, country of birth: Norway). Municipalities and countries of birth not shown in this table. Standard errors in parenthesis.

Appendix Table 7d. Regression results: Confirmed cases per 100 000 by household income, adjusted for age, sex, municipality of residence and country of birth. Beta coefficients.

	Unadjusted	Adjusted for age and sex	Adjusted for age, sex and municipality	Adjusted for age, sex, municipality and country of birth
1st decile	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
2nd decile	-1028.025***	-679.318***	-475.036***	103.473**
	(38.88)	(39.37)	(39.18)	(38.75)
3rd decile	-1402.595***	-1026.397***	-747.666***	111.484**
	(37.57)	(38.23)	(38.05)	(37.47)
4th decile	-1514.683***	-1177.985***	-878.193***	161.924***
	(37.15)	(37.91)	(37.70)	(37.06)
5th decile	-1631.963***	-1352.080***	-1061.104***	100.080**
	(36.72)	(37.48)	(37.26)	(36.54)
6th decile	-1646.332***	-1405.073***	-1133.066***	114.184**
	(36.66)	(37.42)	(37.18)	(36.42)
7th decile	-1685.339***	-1463.018***	-1226.308***	90.791*
	(36.51)	(37.33)	(37.08)	(36.26)
8th decile	-1723.361***	-1503.450***	-1317.099***	57.388
	(36.37)	(37.27)	(37.03)	(36.19)
9th decile	-1795.184***	-1548.492***	-1439.739***	-6.083
	(36.12)	(37.13)	(36.93)	(36.03)
10th decile	-1727.880***	-1387.780***	-1501.729***	0.133
	(36.35)	(37.62)	(37.63)	(36.65)
25-29 years		0.000	0.000	0.000
		(.)	(.)	(.)
30-34 years		-241.306***	-293.056***	-662.402***
		(40.13)	(39.92)	(39.75)
35-39 years		-224.200***	-228.704***	-812.655***
		(40.69)	(40.46)	(40.33)
40-44 years		-303.214***	-269.508***	-768.068***
		(40.69)	(40.47)	(40.28)
45-49 years		-316.985***	-234.041***	-629.461***
		(40.12)	(39.92)	(39.62)
50-54 years		-546.632***	-386.572***	-712.015***
		(38.91)	(38.75)	(38.44)
55-59 years		-837.172***	-631.250***	-929.672***
		(38.45)	(38.30)	(38.00)
60-64 years		-1290.576***	-1029.901***	-1264.665***
		(37.29)	(37.16)	(36.89)
65-59 years		-1728.678***	-1410.654***	-1558.918***
		(35.73)	(35.57)	(35.33)
70-74 years		-1997.764***	-1728.178***	-1746.022***
		(34.92)	(34.75)	(34.54)
75-79 years		-2136.028***	-1923.475***	-1827.083***
		(35.26)	(35.10)	(34.90)
80-84 years		-2296.349***	-2051.763***	-1847.920***
		(37.51)	(37.34)	(37.16)
85-89 years		-2319.840***	-2045.613***	-1716.720***
		(42.86)	(42.68)	(42.49)
90-94 years		-2345.951***	-2073.111***	-1624.442***
		(53.77)	(53.58)	(53.40)
95-99 years		-2440.087***	-2176.542***	-1621.497***
		(86.46)	(86.15)	(85.99)
>=100		-2264.962***	-2022.046***	-1367.365***
		(254.89)	(254.01)	(255.34)

Sex		-138.689***	-165.376***	-67.781***
		(14.24)	(14.18)	(14.13)
Constant	3369.561***	4053.877***	6074.876***	4265.097***
	(29.99)	(38.69)	(47.26)	(46.30)

* p < 0.05, ** p < 0.01, *** p < 0.001. Reference group: Below upper secondary, 25-29 years and male (municipality: Oslo, country of birth: Norway). Municipalities and countries of birth not shown in this table. Standard errors in parenthesis.

Appendix Table 7e. Regression results: Hospitalizations per 100 000 by household income, adjusted for age, sex, municipality of residence and country of birth. Beta coefficients.

	Unadjusted	Adjusted for age and sex	Adjusted for age, sex and municipality	Adjusted for age, sex, municipality and country of birth
1st decile	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
2nd decile	-63.821***	-71.806***	-42.512**	30.432*
	(13.49)	(13.75)	(13.76)	(13.68)
3rd decile	-145.027***	-156.469***	-117.324***	-8.138
	(12.64)	(13.03)	(13.00)	(12.76)
4th decile	-169.352***	-183.182***	-141.114***	-9.818
	(12.37)	(12.78)	(12.75)	(12.49)
5th decile	-190.566***	-205.948***	-165.048***	-20.325
	(12.14)	(12.61)	(12.57)	(12.26)
6th decile	-207.780***	-225.035***	-187.141***	-32.909**
	(11.95)	(12.44)	(12.38)	(12.00)
7th decile	-196.490***	-216.053***	-183.590***	-21.388
	(12.07)	(12.60)	(12.54)	(12.14)
8th decile	-209.009***	-230.495***	-205.679***	-37.267**
	(11.93)	(12.53)	(12.47)	(12.00)
9th decile	-220.158***	-243.652***	-230.378***	-55.149***
	(11.80)	(12.46)	(12.42)	(11.91)
10th decile	-210.711***	-237.475***	-257.554***	-73.407***
	(11.91)	(12.68)	(12.76)	(12.15)
25-29 years		0.000	0.000	0.000
		(.)	(.)	(.)
30-34 years		25.887*	19.761	-20.581
		(10.65)	(10.65)	(10.68)
35-39 years		44.178***	45.753***	-17.990
		(11.06)	(11.06)	(11.15)
40-44 years		41.828***	49.541***	-5.958
		(11.08)	(11.11)	(11.13)
45-49 years		73.326***	89.115***	41.488***
		(11.37)	(11.40)	(11.31)
50-54 years		99.320***	126.097***	82.424***
		(11.58)	(11.64)	(11.52)
55-59 years		98.978***	132.012***	89.411***
		(11.74)	(11.84)	(11.72)
60-64 years		78.859***	118.594***	83.313***
		(11.72)	(11.82)	(11.74)
65-59 years		34.851**	82.141***	56.505***
		(11.32)	(11.42)	(11.34)
70-74 years		31.652**	72.331***	61.630***
		(11.58)	(11.65)	(11.62)
75-79 years		49.706***	83.087***	86.719***
		(12.72)	(12.79)	(12.80)
80-84 years		49.610**	86.777***	103.549***

		(15.50)	(15.56)	(15.61)
85-89 years		29.835	69.595***	102.139***
		(18.79)	(18.82)	(18.86)
90-94 years		-8.895	29.230	77.249**
		(23.92)	(23.92)	(23.94)
95-99 years		-57.513	-22.033	39.875
		(38.06)	(38.02)	(38.04)
>=100		-253.846***	-222.273***	-149.419***
		(8.57)	(9.39)	(9.82)
Sex		-23.518***	-27.083***	-19.179***
		(4.70)	(4.70)	(4.71)
Constant	367.061***	342.802***	649.035***	423.660***
	(10.05)	(11.05)	(14.78)	(14.11)

* p < 0.05, ** p < 0.01, *** p < 0.001. Reference group: Below upper secondary, 25-29 years and male (municipality: Oslo, country of birth: Norway). Municipalities and countries of birth not shown in this table. Standard errors in parenthesis.

Appendix Table 7f. Regression results: Testing per 100 000 by household income, adjusted for age, sex, municipality of residence and country of birth. Beta coefficients.

	Unadjusted	Adjusted for age and sex	Adjusted for age, sex and municipality	Adjusted for age, sex, municipality and country of birth
1st decile	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
2nd decile	-4107.552***	2269.257***	3279.671***	2957.460***
	(116.19)	(113.01)	(112.07)	(112.40)
3rd decile	-3508.183***	4094.095***	5440.945***	5058.628***
	(116.02)	(112.75)	(111.92)	(112.93)
4th decile	-1928.809***	5529.507***	6940.567***	6407.666***
	(116.01)	(112.81)	(112.02)	(113.54)
5th decile	-203.946	6571.127***	7896.132***	7230.669***
	(116.02)	(112.80)	(111.96)	(113.86)
6th decile	1368.327***	7755.007***	8983.465***	8206.297***
	(116.00)	(112.95)	(112.07)	(114.30)
7th decile	1883.447***	8268.612***	9283.633***	8422.508***
	(115.96)	(113.20)	(112.31)	(114.79)
8th decile	2269.449***	8944.804***	9726.963***	8786.299***
	(115.92)	(113.55)	(112.64)	(115.34)
9th decile	1990.958***	9476.001***	9883.170***	8873.860***
	(115.89)	(114.23)	(113.43)	(116.37)
10th decile	1278.012***	10962.193***	10183.069***	9112.145***
	(115.89)	(115.78)	(115.37)	(118.50)
25-29 years		0.000	0.000	0.000
		(.)	(.)	(.)
30-34 years		-2358.438***	-2448.609***	-1933.806***
		(114.24)	(113.23)	(113.23)
35-39 years		-4504.794***	-4343.011***	-3511.132***
		(116.39)	(115.37)	(115.99)
40-44 years		-8248.127***	-7873.632***	-7074.042***
		(118.22)	(117.14)	(117.79)
45-49 years		-13032.552***	-12335.227***	-11818.782***
		(117.59)	(116.59)	(116.95)
50-54 years		-18566.040***	-17415.054***	-17070.148***
		(116.95)	(116.12)	(116.37)
55-59 years		-23177.940***	-21781.053***	-21569.483***

		(119.40)	(118.69)	(118.92)
60-64 years		-27461.790***	-25828.932***	-25700.331***
		(122.04)	(121.49)	(121.62)
65-59 years		-35342.034***	-33395.084***	-33394.880***
		(122.09)	(121.68)	(121.73)
70-74 years		-39701.768***	-37949.243***	-38125.537***
		(121.99)	(121.55)	(121.53)
75-79 years		-40745.142***	-39243.821***	-39539.053***
		(127.67)	(127.14)	(127.13)
80-84 years		-40230.215***	-38610.749***	-38967.066***
		(150.37)	(149.55)	(149.57)
85-89 years		-37142.540***	-35414.571***	-35873.465***
		(185.43)	(183.88)	(183.99)
90-94 years		-33076.707***	-31372.082***	-31898.400***
		(251.80)	(248.57)	(248.64)
95-99 years		-28828.549***	-27243.074***	-27838.989***
		(446.63)	(438.26)	(438.45)
>=100		-26517.400***	-25045.553***	-25620.117***
		(1144.86)	(1126.18)	(1123.77)
Sex		6920.962***	6761.351***	6885.240***
		(49.34)	(48.87)	(49.06)
Constant	48194.109***	57161.743***	64671.399***	65617.655***
	(83.04)	(105.33)	(118.15)	(122.23)

* p < 0.05, ** p < 0.01, *** p < 0.001. Reference group: Below upper secondary, 25-29 years and male (municipality: Oslo, country of birth: Norway). Municipalities and countries of birth not shown in this table. Standard errors in parenthesis.

Published by the Norwegian Institute of Public Health
November 2021
P.O.B 4404 Nydalen
NO-0403 Oslo
Phone: + 47-21 07 70 00
The report can be downloaded as pdf
at www.fhi.no/en/publ/