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Abstract

At the onset of the COVID-19 pandemic, governments in Europe and the US almost universally implemented lockdown measures designed to force social distancing between individuals and thus flatten the curve of COVID-19 infections. Frontline and essential workers nevertheless continued leaving their home and going in to work. We investigate whether there are inequalities in Swedish COVID-19 mortality based on working in frontline occupations or the degree of exposure—measured through contact with others, physical proximity and exposure to disease and infection. Sweden provides a unique case study because it was the only Western country to not employ strong measures but instead rely on recommendations and widespread compliance of its population. We use data the Swedish authorities organized as an early release of all recorded COVID-19 deaths in Sweden up to May 7, 2020, which we link to administrative registers and occupational measures of exposure. Taxi and bus drivers had a higher risk of dying from COVID-19 than other workers, as did older individuals living with service workers. Our findings suggest however that these frontline workers and older individuals they live with are not at higher risk of dying from COVID-19 when adjusting the relationship for other individual characteristics. We also did not find evidence that being a frontline worker in terms of occupational exposure was linked to higher COVID-19 mortality. Our findings indicate no strong inequalities according to these occupational differences in Sweden and potentially other contexts that use a similar approach to managing COVID-19.

Keywords: COVID-19; mortality; occupation; Sweden; exposure

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Introduction

At the onset of the pandemic, the idea that "COVID-19 does not discriminate" (World Health Organisation 2020) was widely held and circulated. Numerous "patient zeros" of COVID-19 were white collar workers who contracted the virus while travelling abroad for work, supporting the idea that everyone could catch the virus. As restrictions and recommendations were put in place to slow the spread of COVID-19 around the world, differential exposure risks emerged. In countries that implemented drastic lockdown measures (also known as phase 1), inequality in exposure risk was based on being a frontline worker or not. In phase 2, in which some or all restrictions were lifted, inequality in risk emerged between those who could work from home and those who could not, as well as those working in public spaces or near the virus and those who did not. Frontline workers have been widely venerated for putting their lives at risk to help others during the outbreak. Indeed, high exposure to people, and therefore potentially to COVID-19, is likely to increase their risk of infection. Whether frontline workers – and the ones they live with – are also at greater mortality risk than other workers due to COVID-19 remains unknown.

Several reports already suggest that men, ethnic minorities, the elderly, and people with existing illnesses have been particularly vulnerable to contracting and succumbing to the virus (Aldridge et al. 2020; Drefahl et al. 2020; Niedzwiedz et al. 2020). We also have evidence of inequalities in infection risk based on migrant status and educational level (Niedzwiedz et al. 2020). Beyond traditional risk factors, we know little about who is most at risk of COVID-19 mortality, particularly in terms of how occupational exposure may play a role. Workers are exposed to the risk of infectious disease based on how much contact with others, physical proximity to others and to diseases they experience at work. Occupations with high exposure span the educational and earnings distribution, including high-earning/high-skilled occupations such as dentists and family practitioners and low-earning/low-skilled occupations such as orderlies. Although COVID-19 mortality should hypothetically increase with increased exposure, individuals working in occupations that are both high-skilled and high exposure may be at less risk of COVID-19 mortality than individuals in low-skilled occupations with similar levels of exposure, due to how traditional risk factors such as educational attainment are related to COVID-19 mortality (Drefahl et al. 2020). The importance of exposure to mortality risk likely varies, in which a high exposure occupation may be particularly deadly for low-skilled individuals.

COVID-19 is found to be most deadly among the elderly (Esteve et al. 2020; Leung 2020) and the age-composition of households may play an important role in diffusion (Giangreco 2020) and fatalities (Arpino et al. 2020; Bayer and Kuhn 2020; Brandén et al. 2020). Working aged individuals do appear to increase the risk of COVID-19 mortality for elderly household members compared to those who do not live with a working age adult (Brandén et al. 2020). The effect of occupation is therefore potentially not only important for the individual worker, but also for those sharing a living space and particularly for the coresidential elderly. But we do not yet know whether it is a general pattern that workers put the older people they live with at risk or rather it is a specific group of frontline occupations that drive these patterns.

In this study, using Swedish individual population registers, we examine inequalities in COVID-19 mortality in Sweden according to characteristics of a working-age individual's occupation, and the indirect effect from this occupation on the COVID-19 mortality of older individuals that are living with them. Sweden is a context that can provide internationally relevant insight into COVID-

19 mortality inequalities because it largely diverged from the international consensus by never formally implementing a lockdown and instead relying on widespread normative compliance to social distancing of its population from the beginning of the pandemic. Despite not mandating a lockdown, according to Google's COVID-19 Community Mobility Report, mobility trends for workplaces decreased 25% in the country as a whole and 36% in Stockholm in March and April (Google LLC 2020). These figures suggest that at least some portion of the population augmented their behavior in response to the global pandemic. After months of mandated quarantining, other governments around the world relaxed some restrictions, aiming instead for a containment strategy of 'living with the virus'. Because of Sweden's immediate entrance into phase 2, it offers a unique case study of COVID-19 mortality inequalities that emerged with this approach.

Material and Methods

We use the Swedish administrative and population registers that include individual-level data on a wide range of socio-economic, demographic, and residential characteristics of all individuals that were living in Sweden in December 2019. This information is linked to the cause of death register updated up until May 8, 2020, which enables us to distinguish recorded COVID-19 mortality from other causes of death.

During the COVID-19 outbreak in Sweden, deaths have been concentrated mostly in the Stockholm region. The study population is restricted to those municipalities in Sweden in which there had been at least one COVID-19 related death by May 8, 2020. We selected two populations for our analyses. First, we selected all those of working age (20-66 at the time of the first observation, March 5), who were registered with an occupation in December 2018: 4,190,014 individuals. More recent occupational information than December 2018 is not yet available in current registers. Second, we selected individuals who were 67 years or older March 5 and lived in a household (in December 2019) with at least one person aged 20-66 that was registered with an occupation in December 2018 – 184,285 individuals. See Supplemental Table 1 for a description of exclusion of cases.

Measures

Outcome variable: We use data on all deaths reported between March 5, 2020 (the date of the first confirmed death by COVID-19 in Sweden) and May 8, 2020, and whether each death was associated with COVID-19. The data on deaths contain all individuals who lived in Sweden, and had been a resident in Sweden for at least two years. These data were collected by the Swedish National Board of Health and Welfare, the agency responsible for the cause of death register. In the study population of working individuals and the elderly living with working individuals, 2,111 individuals in our analytical sample died during the studied period, 334 of these deaths are reported as COVID-19 deaths by the Swedish National Board of Health and Welfare. Of these deaths, COVID-19 was identified as the underlying cause of death in 321 cases (emergency ICD code U07.1, U07.2 or B342). In the remaining 13 cases, ICD emergency codes U07.1, U07.2 or B342 were listed as contributing causes of death but not the underlying cause of death. The confirmed COVID-19 deaths accounted for 70-90% excess mortality in Stockholm during the weeks covered by our data (Folkhälsomyndigheten 2020). Our data capture the (first and only at this time) peak in COVID-19 mortality in Sweden and therefore the great majority of excess deaths in Stockholm and other affected areas of Sweden.

Occupational exposure measure: We draw on publicly available data through the O*NET online database (version 24.2) (https://www.onetonline.org/) that is supported by the US Department of Labor/Employment and Training Administration. The occupational exposure information has been constructed for the Standard Occupational Classification System (SOC) in the US and we matched SOC codes to the International Standard Classification of Occupations (ISCO-08) first, using the crosswalk procedure provided by Hardy et al. (2018), and then matched ISCO-08 codes to the Swedish Standard Classification of Occupations (SSYK 2012) with the occupational code key provided by Statistics Sweden (SCB n.d.). O*NET data has been applied in scientific research on health outcomes (for a review, see Cifuentes et al. 2010), as well as widely discussed in reports and media in relation to COVID-19 (Gamio 2020; Hicks et al. 2020; Leibovici et al. 2020; Lu 2020; Wardrip and Tranfaglia 2020). The index we use is a combined measure of three work context measures that are all relevant to the spread of COVID-19 and that are not likely to vary across cultures and institutional contexts: how much the job requires contact with others, how close the physical proximity is to people, and the frequency of exposure to disease and infection. We generated an unweighted mean of these three work context measures to arrive at our occupational exposure index. The index is measured on a continuous scale ranging between 0 and 100. An index score of 100 represents constant exposure to infection, contact with others and near physical proximity. The highest score (98.7) is found for dental hygienists and the lowest score (24.8) is found for video game designers.

In addition to the continuous measure capturing exposure (described above) we construct occupational groups using the Swedish occupational registers. First, we distinguish between manual and skilled workers using a key constructed by Statistics Sweden (SCB n.d.). The occupational exposure information we use was generated on the basis of work environments in a non-pandemic time period and by introducing these distinctions we aim to capture differences in a time of pandemic related to whether individuals can control their work environment and, for example, more likely work at home. Workers in high exposure occupations that are also skilled may be able to reduce work hours to reduce infection risk because they have higher income and lifetime earnings. We then distinguish between detailed occupational groups that are widely considered to be frontline and/or essential occupations: care workers, police officers and security guards, service sector personnel, delivery workers, taxi- and bus drivers, teachers, meat packers, and cleaners. We compare the COVID-19 mortality risk of these workers to IT technicians, which are not frontline workers, as well as all other occupations combined. The occupational group approach provides an alternative strategy to the analyses based on the exposure index and allows us to isolate any specific group that is at risk. For a full list of the SSYK 2012 in each occupation, see Supplemental Table 2.

For the population aged 20-66, we measure one’s own primary occupation, whereas for the population aged 67+ we measure the primary occupation of other individuals aged 20-66 in the household.

In the fully adjusted models, we control for age, sex, country of birth, living in Stockholm (measured at the end of 2019), highest achieved educational degree, and individual net income (measured at the end of 2018).

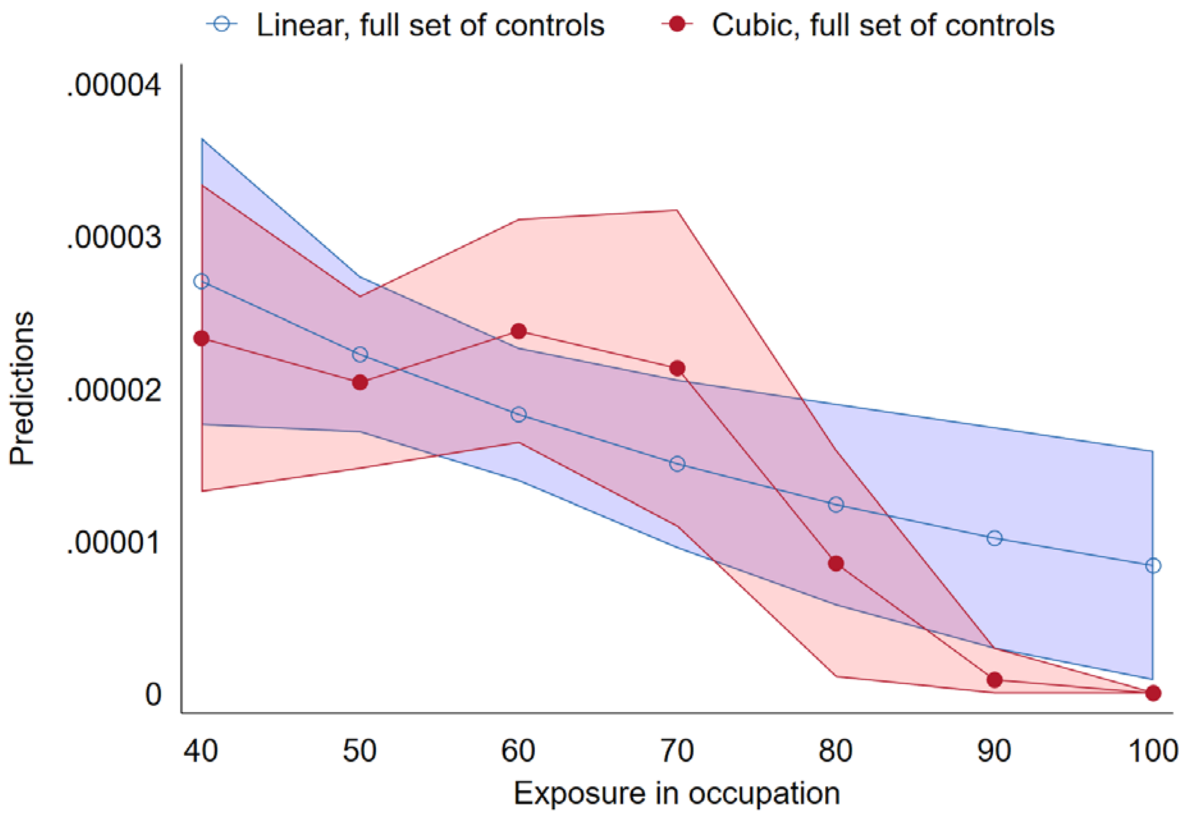
Method

We performed Poisson regressions with COVID-19 death as an event, with the log of the follow-up time as an offset in the models (Austin 2017). The follow-up time began March 5, 2020 and ended (1) by dying of any cause between starting time and May 8, 2020, or (2) being alive on May 8, 2020. Robust standard errors were used in all models. All analyses were conducted using Stata Statistical Software: Release 16 (StataCorp LP, College Station, Texas).

Results

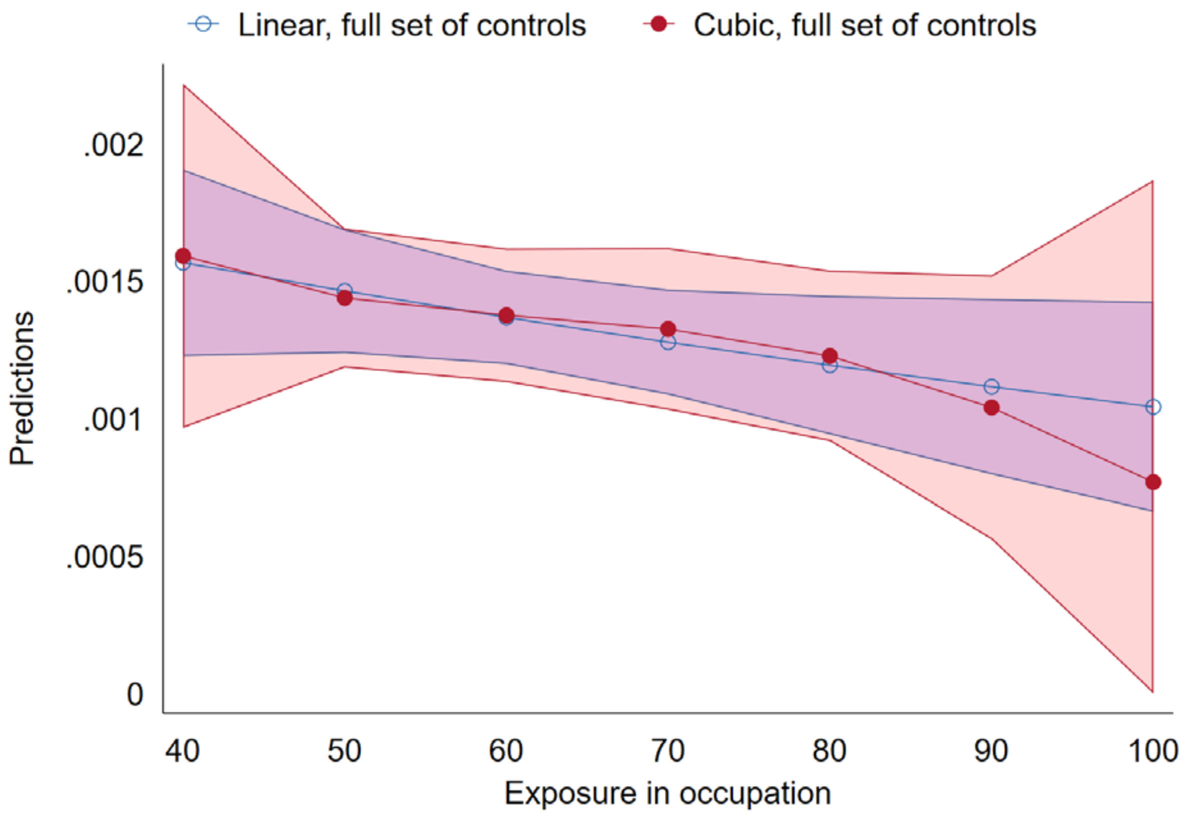
Descriptive statistics of the population and covariates are available in Supplemental Table 3. Figure 1 displays results from the association between occupational exposure and COVID-19 mortality (also see Supplemental Table 4) in terms of predicted mortality risk. The blue slopes represent the estimates when the relationship is restricted to be linear to the log of the mortality risk; we therefore allow the speed of decrease or increase to vary according to the exposure level. We might expect that as exposure to disease and people as well as physical proximity to people increases, the risk of contracting COVID-19 and dying from it also increases. However, even when this relationship is adjusted for age, sex, income, education, country of origin, and living in Stockholm, it appears relatively flat, with a very slight negative slope, in which those with higher occupational exposure to people and disease have a lower risk of COVID-19 mortality than those with lower exposure. When relaxing the assumption of linearity and estimating the relationship with a quadratic term instead, the model fit did not improve (according to the Akaike information criterion (AIC)) and the terms were not statistically significant with or without additional controls (not presented but available upon request). The model fit according to AIC did slightly improve when we assumed a cubic relationship and the cubic term was statistically significant, which means there are multiple increases and decreases in the log of mortality risk according to the exposure index. In Figure 1, we restricted the scale to a lower bound of 40, which is where 97% of all occupations are located in the distribution and we can achieve more reliable confidence intervals. The red line shows that the association between mortality and exposure is relatively flat, with a slight increase around a score of 60 on the exposure index (e.g., construction worker) when adjusting for socioeconomic and demographic characteristics. A more marked decrease is observed at the highest exposures of 80-100, which is where the majority of occupations in health care are located. Despite what might be expected, we find very little difference in COVID-19 mortality risk by occupational exposure and the differences that do exist are in the opposite direction to expectations at the highest exposures.

Fig 1. Predicted margins of COVID-19 mortality for 20-66 year olds: the association with occupational exposure index, estimated as a linear and cubic relationship, 95% confidence intervals.



In Figure 2, we similarly explore the relationship between occupational exposure and the mortality of an older person in the household (also see Supplemental Table 5). Both assuming a linear or cubic relationship between exposure and the log of mortality yield results that are quite similar showing a mostly flat, but slightly negative slope. The differences between the point estimates are not statistically significant.

Fig 2. Predicted margins of COVID-19 mortality for 67+ year olds: the association with occupational exposure index of worker(s) in the household, estimated as a linear and cubic relationship, 95% confidence intervals.



Returning to working-age individuals, we explore the relationship between occupational exposure and COVID-19 mortality further in Figure 3 (also presented in Supplemental Table 4) by stratifying occupations according to whether they are manual (blue line) or skilled workers, including managerial (red line).

When looking at skilled workers, the association between COVID-19 mortality and exposure is positive at lower degrees of exposure and negative at higher degrees of exposure. The peak in the relationship between exposure and mortality is around 40-50 (e.g., graphic designer and supervisor in warehouse or terminal) when we adjust our model for other factors than sex and age. On the other hand, the pattern for manual workers shows a similar trend as in Figure 1, with the highest mortality risk peaking at around 70 (e.g., bus driver). Despite these different patterns, the confidence intervals for the manual and skilled worker mortality estimates overlap substantially.

Figure 4 (also presented in Supplemental Table 5) shows how manual and skilled occupational exposure is related to the COVID-19 mortality risk of older individuals in the household. We see similar patterns for this age group, including an elevation in predicted mortality in the range of 70 to 80 for manual workers. Although the lines appear flatter in the figure for older people than younger people, the increases and decreases in point estimates are greater for the older population, but these differences are not statistically significant.

Fig 3. Predicted margins of COVID-19 mortality for 20-66 year olds: the association with occupational exposure index, estimated separately for manual and skilled workers, 95% confidence intervals.

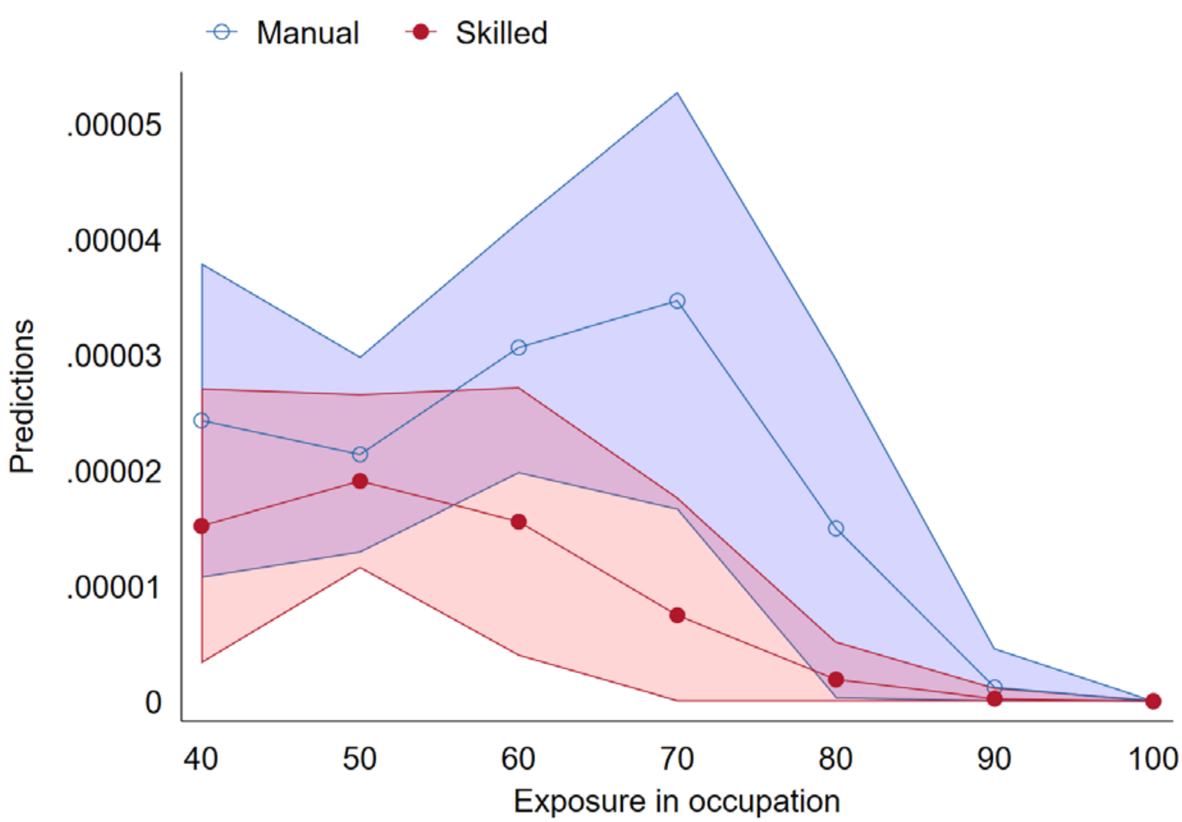


Fig 4. Predicted margins of COVID-19 mortality for 67+ year olds: the association with occupational exposure index of worker(s) in the household, estimated separately for manual and skilled workers, 95% confidence intervals.

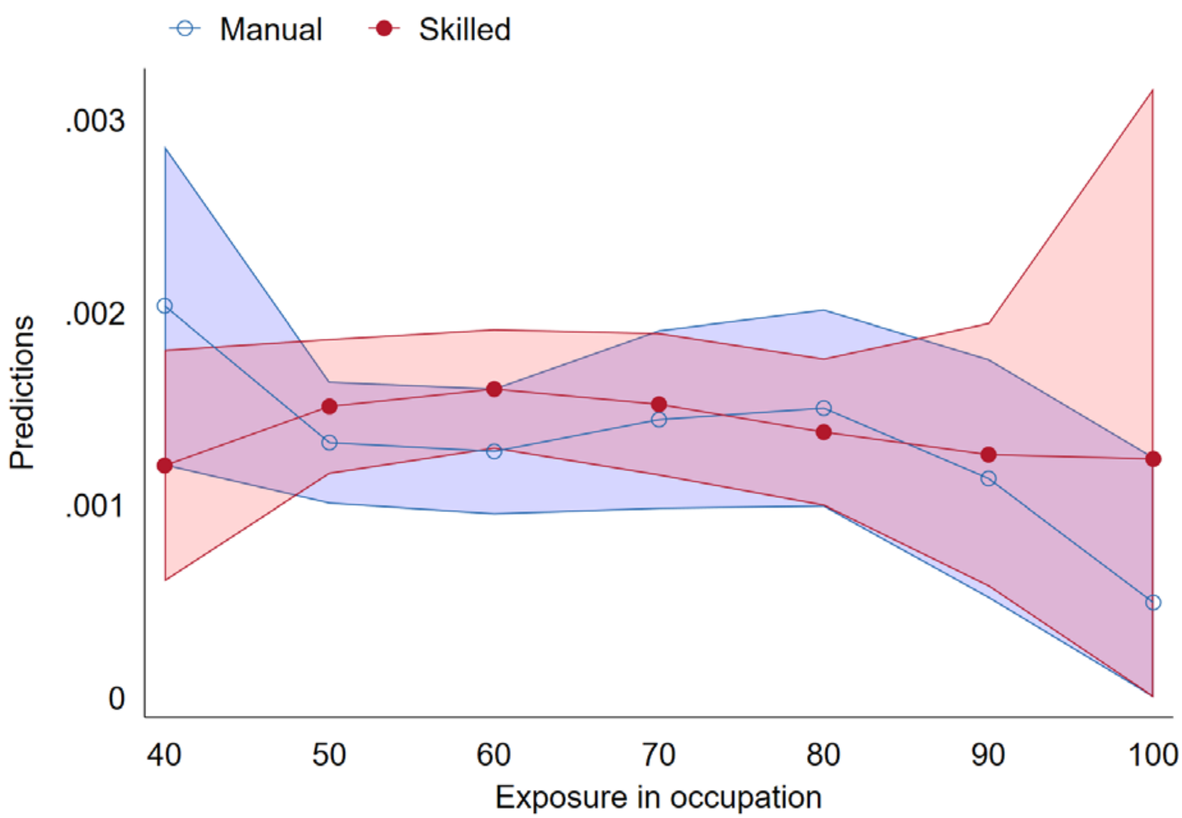


Table 1. COVID-19 mortality risk ratios according to own occupational group (ages 20-66) or worker(s) in the household (for those 67+). Adjusted for sex and age (Models 1 and 3) and full set of controls (Models 2 and 4). Standard errors and p-values.

	Young population, own occupation						Old population, household members' occupations					
	Model 1			Model 2			Model 3			Model 4		
	RR	min95	max95	RR	min95	max95	RR	min95	max95	RR	min95	max95
Occupation												
Other	2.54	0.35	18.32	2.07	0.29	14.86	1.14	0.75	1.74	1.16	0.78	1.74
Care workers	0.60	0.04	9.59	0.37	0.02	5.72	0.78	0.47	1.30	0.77	0.47	1.27
Taxi- and bus drivers	12.22	1.51	98.59	3.71	0.46	30.02	0.84	0.26	2.71	0.59	0.19	1.89
Meat packers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Teachers	0.89	0.06	13.94	0.65	0.04	10.07	1.00	0.60	1.66	0.91	0.55	1.51
Service sector	5.18	0.61	43.72	2.22	0.26	18.67	1.56	1.01	2.39	1.29	0.84	1.96
Police men, security guards	0.00	0.00	0.00	0.00	0.00	0.00	1.98	0.78	5.04	1.58	0.63	3.96
Postal workers, delivery	0.00	0.00	0.00	0.00	0.00	0.00	1.44	0.45	4.67	1.15	0.35	3.71
Cleaners	5.04	0.45	55.97	1.23	0.11	13.67	1.18	0.62	2.27	1.00	0.52	1.91
IT technicians	1.00			1.00			1.00			1.00		
N	4190014			4190014			184285			184285		

Table 1 shows mortality risk ratios from COVID-19 within different occupations that are often discussed as frontline occupations and essential workers (Folkhälsomyndigheten 2020). We chose IT technicians as a reference group because they are a large group that can generally work from home. When adjusted only for sex and age, only taxi and bus drivers have a statistically significant higher risk of dying from COVID-19 (RR = 12.22, 95% CI = 1.51-98.59) than IT technicians. For meat packers, police men, and postal/delivery workers, the risk is zero because there have been no COVID-19 deaths in those occupations. In the fully adjusted model, the mortality risk for bus and taxi drivers is still substantially higher, but no longer statistically different from IT technicians. When looking at how occupations are related to the death of older individuals in the household in the model adjusted only for sex and age, we find that old individuals co-residing with someone working in the service sector have higher mortality than those co-residing with an IT-technician (RR = 1.56, 95% CI =1.01-2.39). In the fully controlled models, we do not find any statistically significant differences.

Discussion

Our investigation into whether inequalities in COVID-19 mortality appear to be related to the work environment is motivated by the demand for certain workers to continue leaving their home and show up to work even in the midst of a pandemic. Frontline and essential workers have faced grave and uncertain consequences for their lives and for their family with the relentless spread of COVID-19. Our findings provide a somewhat optimistic perspective for these workers, as there is little evidence that they, or older individuals in the household, are more likely to die from COVID-19 than other workers from a wide range of occupations and occupational exposure to people and disease.

Although this finding may be counterintuitive, it is plausible in light of a few factors. First, workers that are nearest to COVID-19 (doctors and nurses) are healthcare workers, who are the most likely of all to be provided personal protective equipment (PPE) and be trained in how to use them appropriately. These include respiratory protection, face visors, protective aprons and protective gloves. Sweden adheres to the EU regulation 2016/425 on PPEs and the Swedish Work Environment Agency regularly checks compliance. Although Sweden was unprepared for the increased need for PPEs due to the pandemic according to a report issued by the leading medical associations and trade unions in March, 2020, workers with the highest occupational exposure were likely to have some form of protection (Vårdförbundet et al. 2020). We found some indication of a higher COVID-19 mortality risk for moderate levels of occupational exposure and these are work environments in which workers would generally not be wearing PPEs of the sort to protect against disease, but still come in contact with others regularly. High risk environments such as hospitals are also more likely to provide PPEs to workers as part of the work environment rather than lower risk environments in which the cost may be carried by the worker.

Because we are analyzing mortality instead of infection rates, patterns may be driven also by the frailty and health behavior characteristics of individuals in the occupations. These characteristics correlate with socioeconomic status (Adler and Newman 2002; Fox et al. 1985; Halleröd and Gustafsson 2011; Mackenbach et al. 2016; Mishra et al. 2013; Pampel et al. 2010), which is why it is important to adjust the relationship between occupational exposure and mortality for factors such as educational attainment and income. But we are not able to adjust for factors such as individuals being sorted into work on the basis of health (Chandola et al. 2003; Halleröd and Gustafsson 2011; Manor et al. 2003) or experiencing health conditions directly due to their work environment (Evans and Kantrowitz 2002). In addition, we likely see better health-seeking behavior in the highest exposure occupations because they are specifically trained in health care and they may have better access to health care because they are more likely to know how to navigate the health system. All of these factors may contribute to the lack of a clear relationship between occupational exposure and COVID-19 mortality.

One occupational group stands out in our analysis as being particularly at risk, however. Bus and taxi drivers have a substantially heightened COVID-19 infection risk (Folkhälsomyndigheten 2020) and our study shows that they also have a substantially heightened mortality risk. Our finding does not extend to the older people with which they may be living, however, and the difference between them and other workers was diminished when adjusting for individual characteristics. Nevertheless, drivers' high COVID-19 mortality risk is not surprising given the nature of their work and the COVID-19 virus. Cars and buses may be a hot zone if many people come in and out over the course of a shift because COVID-19 does not quickly fall out of enclosed air (Lewis 2020). On the other hand, taxi and bus drivers do not spend much time together and therefore are not at risk of spreading it to each other. At the least, this renders this particular finding highly generalizable because it cannot be driven by a superspreader event such as a conference occurring early on in the pandemic or due to cluster spreading, in which the virus is transmitted in a single work environment, such as in the case of meatpackers in Germany and the mining town of Gällivare in northern Sweden. Efforts to determine which PPEs can protect drivers best and provision of those PPEs are very important.

Another occupational group seems to be risky in terms of coresidential elderly; those who are 67 years or older that are living with younger individuals working in the service sector also have a higher risk of COVID-19 mortality, but this risk is not as pronounced as the increased risk found for bus and taxi drivers. And once again, it did not continue to be a risk factor once we adjusted for the older person's characteristics.

One other finding worth discussing on its own is the low COVID-19 mortality risk of children's and adolescents' teachers (Cohen et al. 2020; Debatin et al. 2020; RIVM 2020). Sweden did not shut down schools for these age groups, which have been viewed as a potential transmission source in other countries. While this is not direct evidence related to the looming questions about how children spread COVID-19 and whether open schools are dangerous (Couzin-Frankel et al. 2020; Fontanet et al. 2020), the finding that teachers do not appear to be a high risk group in Sweden may contribute one more piece of evidence to the ongoing discussion.

Sweden offers a good example of phase 2 conditions, but the extent to which our results are generalizable to other contexts may be limited if, for example, PPEs were more widely available in Sweden or other health care practices were in place that protected workers better in Sweden than elsewhere. On the other hand, Sweden is also unique because it is one of the few countries that did not adopt mask-wearing as a practice to limit the spread of COVID-19. Were all customers to wear appropriate masks, the risk to drivers and service sector workers, for example, may have been less (Hendrix et al. 2020). Another contextual factor to consider is whether the high income replacement benefits for both short and long term sick leave in Sweden influence whether individuals with poor health are in the labor market less than in contexts providing lower social benefits such as the US. This has implications for how a healthy worker effect operates within specific occupations, which would influence the differences between occupational groups, as well as how likely sickness presenteeism is, in which people who are ill do not stay home.

In sum, our findings suggest that there are no real specific risk groups according to being a frontline or essential worker, as is commonly stated in the media, when strict social distancing restrictions are not in place, as was the case in Sweden during this time period. Frontline workers may, nevertheless, still be bearing the brunt of the pandemic in Sweden even if they are not dying more. They may still be facing a higher infection risk (especially if there are shortages of PPEs), more sickness, extra stress, and longer work hours if more coworkers are sick.

Our findings suggest that COVID-19 has not discriminated in Sweden to the extent that it might have in other contexts with more strict restrictions. Because of our unique setting, our results cannot speak to the racial and ethnic differences emerging in other settings (Oppel Jr et al. 2020) in which non-essential workers, who are often of the majority ethnic group, are able to remain at home and the exposure difference between frontline workers and those who are not is likely greater and correlated with ethnicity and race. However, individuals that were not born in Sweden have a higher risk of COVID-19 mortality than those born in Sweden (Drefahl et al. 2020) and how this inequality relates to differential occupational exposure and the complexity of other systemic differences (Smith 2000) is an important area of future research.

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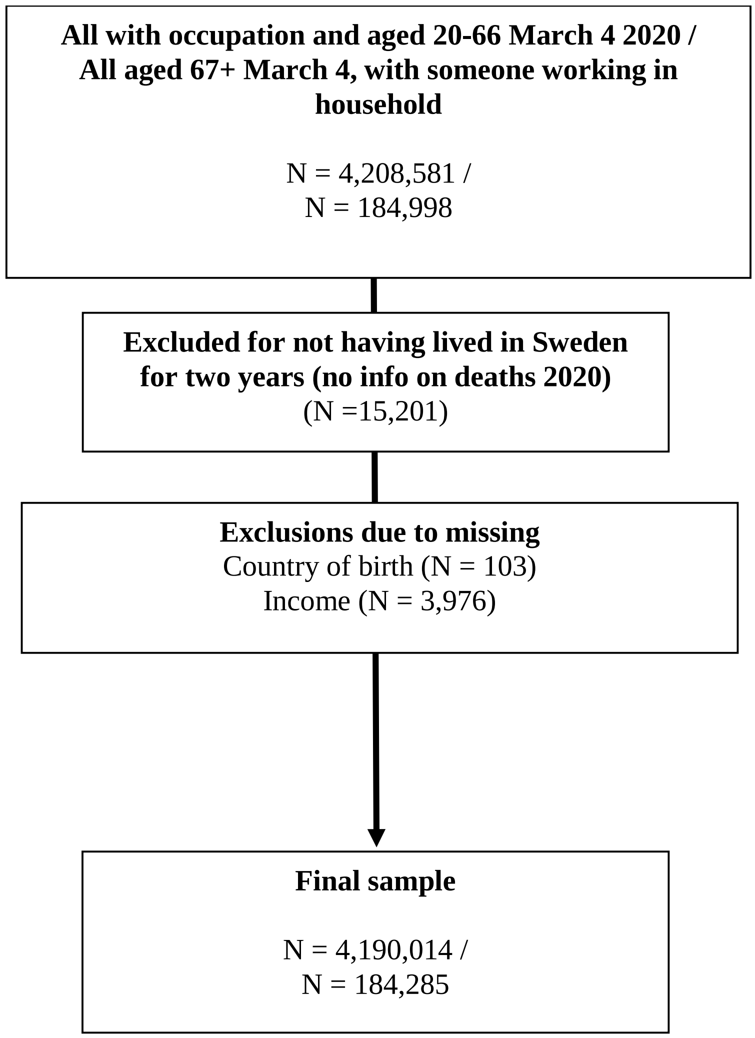
Supplemental Table 1. Selection flow and final population



Supplemental Table 2. Swedish occupational codes included in occupational groups

	SSYK
Care workers	221, 222, 223, 532, 533; excluding 2222, 2225, 2233, 2234
Taxi- and bus drivers	8321, 8331
Meat packers	7611
Teachers	234, 5311
Service sector	522, 941, 523
Police men, security guards	5412, 5413, 3360
Postal workers, delivery	4420, 8329
Cleaners	9111
IT technicians	251

Supplemental Table 3. Descriptive statistics for studied population

Note: Occupational characteristics refer to own occupation for individuals aged 20-66, and for household members aged 20-66 for individuals aged 67+

	Aged 20-66				Aged 67+			
	N at March 5	% / mean	N dead from COVID-19	N dead per 1000 from COVID-19 / mean if dead from COVID-19	N at March 5	% / mean	N dead from COVID-19	N dead per 1000 from COVID-19 / mean if dead from COVID-19
Exposure in occupation (mean)	.	58.3	.-	54	.	62.02	.	60.41
Skilled or manual worker								
Manual	2,038,237	48.6	51	0.03	85,653	46.5	119	1.39
Skilled	1,873,933	44.7	26	0.01	103,079	55.9	154	1.49
Managerial	277,844	6.6	7	0.03	11,742	6.4	18	1.53
Occupation								
Other	2,911,349	69.5	65	0.02	130,019	70.6	189	1.45
Care workers	374,244	8.9	[< 5]	0	25,693	13.9	24	0.93
Taxi- and bus drivers	350,20	0.8	8	0.23	2,081	1.1	[< 5]	1.44
Meat packers	2,964	0.1	[< 5]	0	141	0.1	[< 5]	0
Teachers	279,481	6.7	[< 5]	0	17,277	9.4	20	1.16

Service sector	317,710	7.6	6	0.02	15,803	8.6	33	2.09
Police men, security guards	42,035	1	[< 5]	0	1,688	0.9	5	2.96
Postal workers, delivery	25,490	0.6	[< 5]	0	1,446	0.8	[< 5]	2.07
Cleaners	78,502	1.9	[< 5]	0.03	6,272	3.4	10	1.59
IT technicians	123,219	2.9	[< 5]	0.01	3,713	2	8	2.15
Age								
-44	2,245,221	53.6	5	0	.	.	.	.
45-49	496,597	11.9	5	0.01	.	.	.	.
50-54	497,317	11.9	14	0.03	.	.	.	.
55-59	441,473	10.5	19	0.04	.	.	.	.
60-64	387,228	9.2	27	0.07	.	.	.	.
65-69	122,178	2.9	14	0.11	77,482	42	20	0.26
70-74	.	.	.	.	59,223	32.1	35	0.59
75-79	.	.	.	.	24,607	13.4	47	1.91
80-84	.	.	.	.	12,235	6.6	53	4.33
85-89	.	.	.	.	6,908	3.7	48	6.95
90-94	.	.	.	.	3,021	1.6	33	10.92
95+	.	.	.	.	809	0.4	14	17.31
Sex								
Man	2,107,091	50.3	71	0.03	123,464	67	140	1.13

Woman	2,082,923	49.7	13	0.01	60,821	33	110	1.81
Country of birth								
Sweden	3,377,490	80.6	45	0.01	146,151	79.3	147	1.01
HIC	231,612	5.5	8	0.03	18,328	9.9	37	2.02
LMIC other	397,831	9.5	19	0.05	13,311	7.2	39	2.93
LMIC MENA	183,081	4.4	12	0.07	6,495	3.5	27	4.16
Education								
Primary	356,256	8.5	17	0.05	49,029	26.6	88	1.79
Secondary	1,910,342	45.6	45	0.02	73,679	40	88	1.19
Post-Secondary	1,889,754	45.1	22	0.01	56,815	30.8	48	0.84
Missing	33,662	0.8	[< 5]	0	4,762	2.6	26	5.46
Income								
Lowest tertile	635,072	15.2	16	0.03	72,783	39.5	153	2.1
Mid tertile	1,596,711	38.1	36	0.02	59,771	32.4	65	1.09
Highest tertile	1,958,231	46.7	32	0.02	51,731	28.1	32	0.62
Stockholm vs. rest								
Rest of Sweden	3,091,459	73.8	35	0.01	139,247	75.6	89	0.64
Stockholm county	1,098,555	26.2	49	0.04	45,038	24.4	161	3.57
TOTAL	**4,190,014**	**100**	**84**	**0.02**	**184,285**	**100**	**250**	**1.36**

Supplemental Table 4. Full Poisson regression results, ages 20-66 with a registered occupation

	Model 1			Model 2			Model 3			Model 4		
	All aged 20-66 with an occupation			All aged 20-66 with an occupation			Manual workers aged 20-66			Skilled workers and managers aged 20-66		
	RR	se	p	RR	se	p	RR	se	p	RR	se	p
Exposure in occupation	0.98	0.01	0.045	0.44	0.17	0.034	0.32	0.14	0.011	1.09	1.04	0.927
Exposure in occupation ^2				1.02	0.01	0.029	1.02	0.01	0.011	1.00	0.02	0.978
Exposure in occupation ^3				1.00	0.00	0.023	1.00	0.00	0.010	1.00	0.00	0.854
Age												
<44	1	.	.	1	.	.	1	.	.	1	.	.
45-49	5.50	3.53	0.008	5.55	3.56	0.008	3.89	3.61	0.144	8.22	7.52	0.021
50-54	15.96	8.39	0.000	16.14	8.48	0.000	19.48	13.04	0.000	11.91	10.03	0.003
55-59	24.22	12.32	0.000	24.52	12.45	0.000	21.34	14.25	0.000	30.69	23.66	0.000
60-64	42.12	20.86	0.000	42.61	21.06	0.000	41.79	27.08	0.000	45.35	34.32	0.000
65-66	73.91	38.96	0.000	75.01	39.48	0.000	91.27	61.43	0.000	51.42	44.38	0.000
Sex												
Man	5.13	1.65	0.000	4.98	1.55	0.000	6.13	2.80	0.000	4.51	1.91	0.000
Woman	1	.	.	1	.	.	1	.	.	1	.	.
Country of birth												
Sweden	1	.	.	1	.	.	1	.	.	1	.	.

HIC	1.80	0.71	0.136	1.77	0.70	0.147	2.32	1.10	0.075	1.12	0.83	0.883
LMIC other	4.12	1.18	0.000	3.95	1.14	0.000	4.46	1.59	0.000	3.59	1.96	0.019
LMIC MENA	4.49	1.54	0.000	4.21	1.45	0.000	4.16	1.76	0.001	5.25	3.17	0.006
Education												
Primary	1.71	0.55	0.096	1.62	0.52	0.133	2.44	1.30	0.095	1	0.75	0.995
Secondary	1.72	0.46	0.042	1.65	0.44	0.060	2.23	1.13	0.115	1.38	0.51	0.388
Post-Secondary	1	.	.	1	.	.	1	.	.	1	.	.
Missing	0.00	0.00	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.00	0.00	0.000
Income												
Lowest tertile	2.46	0.81	0.006	2.29	0.76	0.012	1.51	0.64	0.337	5.06	2.56	0.001
Mid tertile	1.94	0.51	0.012	1.82	0.48	0.022	1.36	0.45	0.361	3.26	1.25	0.002
Highest tertile	1	.	.	1	.	.	1	.	.	1	.	.
Stockholm vs. rest												
Rest of Sweden	1	.	.	1	.	.	1	.	.	1	.	.
Stockholm county	4.24	0.96	0.000	4.15	0.94	0.000	3.59	1.03	0.000	4.87	1.90	0.000
Constant	0	0	0.000	0	0.03	0.428	0.63	5.03	0.954	0	0	0.189
N	4,190,014			4,190,014			2,038,237			2,151,777		

Supplemental Table 5. Full Poisson regression results, ages 67+ living with a person <67 with a registered occupation

	Model 1			Model 2			Model 3			Model 4		
	All aged 67+ with someone aged 20-66 with an occupation in household			All aged 67+ with someone aged 20-66 with an occupation in household			Aged 67+ with a manual worker in household			Aged 67+ with a skilled worker or manager in household		
	RR	se	p	RR	se	p	RR	se	p	RR	se	p
Exposure in occupation	0.99	0.00	0.127	0.91	0.23	0.705	0.60	0.14	0.024	1.19	0.29	0.474
Exposure in occupation ^2				1.00	0.00	0.709	1.01	0.00	0.031	1.00	0.00	0.542
Exposure in occupation ^3				1.00	0.00	0.696	1.00	0.00	0.041	1.00	0.00	0.618
Age												
67-69	1	.	.	1	.	.	1	.	.	1	.	.
70-74	2.14	0.60	0.007	2.14	0.60	0.007	2.74	1.11	0.013	1.67	0.59	0.141
75-79	6.58	1.80	0.000	6.58	1.80	0.000	5.63	2.39	0.000	6.62	2.15	0.000
80-84	15.22	4.28	0.000	15.23	4.28	0.000	16.88	7.14	0.000	12.81	4.29	0.000
85-89	25.73	7.40	0.000	25.74	7.40	0.000	38.12	16.01	0.000	18.63	6.47	0.000
90-94	42.44	12.97	0.000	42.46	12.97	0.000	69.18	30.07	0.000	32.02	12.00	0.000
95+	62.31	23.49	0.000	62.45	23.52	0.000	106.71	55.30	0.000	37.42	18.36	0.000
Sex												
Man	1.39	0.19	0.016	1.38	0.19	0.016	1.45	0.29	0.061	1.28	0.21	0.122
Woman	1	.	.	1	.	.	1	.	.	1	.	.

Country of birth												
Sweden	1	.	.	1	.	.	1	.	.	1	.	.
HIC	1.12	0.22	0.561	1.12	0.22	0.562	0.62	0.20	0.141	1.43	0.33	0.124
LMIC other	1.85	0.35	0.001	1.85	0.35	0.001	1.87	0.55	0.035	1.99	0.45	0.002
LMIC MENA	2.60	0.63	0.000	2.59	0.63	0.000	2.05	0.79	0.061	2.86	0.85	0.000
Education												
Primary	1.43	0.27	0.053	1.43	0.27	0.055	1.38	0.37	0.225	1.44	0.35	0.132
Secondary	1.42	0.25	0.049	1.41	0.25	0.050	1.37	0.31	0.164	1.57	0.38	0.061
Post-Secondary	1	.	.	1	.	.	1	.	.	1	.	.
Missing	1.06	0.29	0.834	1.06	0.29	0.838	0.72	0.32	0.469	1.33	0.42	0.371
Income												
Lowest tertile	1.15	0.26	0.538	1.15	0.26	0.547	1.03	0.32	0.934	1.13	0.34	0.687
Mid tertile	1.11	0.25	0.655	1.1	0.25	0.664	1.24	0.36	0.467	0.95	0.29	0.855
Highest tertile	1	.	.	1	.	.	1	.	.	1	.	.
Stockholm vs. rest												
Rest of Sweden	1	.	.	1	.	.	1	.	.	1	.	.
Stockholm county	4.92	0.70	0.000	4.92	0.71	0.000	5.38	1.10	0.000	4.57	0.82	0.000
Constant	0.00	0.00	0.000	0.00	0.00	0.024	0.05	0.22	0.509	0.00	0.00	0.000
N	184,285			184,285			85,653			112,933		

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