The Pandemic Predominantly Hits Poor Neighbourhoods, or does it?

SARS-CoV-2 Infections and Covid-19 Fatalities in German Local Districts

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Abstract (250 words)

Background

Reports from the UK and the USA suggest that COVID-19 predominantly affects poorer neighbourhoods. This article paints a more complex picture by distinguishing between a first and second phase of the pandemic. The initial spread of infections and its correlation with socio-economic factors depends on how the virus first entered a country. The second phase of the pandemic begins when individuals start taking precautionary measures and governments implement lockdowns. In this phase the spread of the virus depends on the ability of individuals to socially distance themselves, which is to some extent socially stratified.

Methods

We analyse the geographical distribution of known cumulative cases and fatalities per capita in an ecological analysis across local districts in Germany distinguishing between the first and the second phase of the pandemic.

Results

In Germany, the virus first entered via individuals returning from skiing in the Alps and other international travel. In this first phase we find a positive association between the wealth of a district and infection rates and a negative association with indicators of social deprivation. During the second phase and controlling for path dependency, districts with a higher share of university-educated employees record fewer new infections and deaths and richer districts record fewer deaths, districts with a higher unemployment rate record more deaths.

Conclusion

The social stratification of Covid-19 changes substantively across the two phases of the pandemic in Germany. Only in the second phase and controlling for temporal dependence does Covid-19 predominantly hit poorer districts.

Key words

* Covid-19

* Sars-CoV-2

* lockdown

Introduction

It is a recurrent theme in the public health literature that during a pandemic, low-income populations will be infected with a higher probability.[1,2,3] In line with this established argument, recent media reports from the United Kingdom,[4] data from the US,[5] an academic study of Covid-19 mortality in New York City,[6] and an analysis of Covid-19 mortality across US districts and New York postcodes[7] consistently suggest that the poor are more likely to get infected with Sars-CoV-2 and develop Covid-19 and that poor neighbourhoods will bear the brunt of the pandemic. In other countries, however, Covid-19 is perceived to be a 'rich man's disease'. In many developing countries, the coronavirus was imported via business travellers from China, students from Europe, or by tourists,[8] and in European countries a good part of the spread can be traced back to ski tourism in the Alps.[9]

The argument that Covid-19 affects and kills predominantly the poor and socially deprived cannot be generalized to all countries and the link between socio-economic factors and who bears the major burden of the pandemic is more complex. Our argument rests on a distinction between two phases of the pandemic. In phase 1 the first importation of the virus from abroad and its subsequent initial spread will depend to some extent on pure chance. The correlation of infections with socio-economic factors is strongly influenced by the channels through which the virus enters a country. This initial phase is characterized by widespread ignorance first and neglect later on. The existence of the virus may be known – European citizens had seen footage from China and Italy – but the ability to test for a Sars-

CoV-2 infection remains underdeveloped,[10] very few people had adjusted their behaviour and governments had not yet implemented social distancing measures.

In Germany, the virus happened to be spread initially via individuals returning from ski holidays in the Alps and, to a much lesser extent, through business and other travellers from China, Italy and other hotspots, which meant that the majority of infected people in the beginning were relatively young and well-off.[9,11] Once the virus had reached Germany, the subsequent spread of infections was facilitated by super-spreader social events such as a carnival session in Gangelt, a small town in the district of Heinsberg, a beer festival in the small city of Mitterteich, district of Tirschenreuth, and a wine event in Bretzfeld, Hohenlohekreis. These super-spreader events create local cluster effects if the social event is mainly attended by locals. In fact, even two months after the above events took place, these were still the districts with the highest number of known infections per 100,000 citizens in Germany.

Map 1 displays cumulative known Sars-CoV-2 cases, normalized by population, in German districts on 13 April. Even at a first glance we see that the rate of infection declines from South to North and from West to East. Even within the Western part of Germany, regions in which a greater share of the population is Catholic also have a higher incidence, which may be correlated to spreader events such as carnival that is much more popular in predominantly Catholic regions.[12,13] The North-South divide appears to be stronger than the East-West divide. This may be down in part to the greater ease by which Southern Germans can reach by car what turned out to be virus hotspots in ski resorts in Northern Italy and Austria.

insert figure 1 about here

Once the existence and dangers of the pandemic have become public knowledge, people and governments implement precautionary measures and the spread of the virus slows down.[14,15] At the same time, the geographical pattern of infections slowly changes. For a virus to spread, social interaction between an infected and an uninfected person is required. Since the number of new infections remains strongly influenced by the number of active infections in a district, the pattern that has evolved during phase 1 will not disappear quickly. Thus, hotspots remain hotspots for some time.

But not forever. Map 2 shows the distribution of cumulative new positive Sars-Cov-2 tests between 14 April and 19 May. Whilst the North-South and East-West divides are still present, clearly the distribution of new infections already starts to look different from the distribution of cumulative cases on 13 April.

insert figure 2 about here

In phase 2 of the pandemic and despite the enduring and strong path-dependency, which map 2 visualizes, the correlation of the spread of the infection with socioeconomic factors changes. In the second phase, individuals reduce social interactions, governments implement lockdown measures and recommend social distancing especially to people perceived as vulnerable. During the second phase of the spread of the virus, the ability of individuals to reduce social interactions becomes the decisive factor. Lockdown measures do not affect all people in the same way.[16] The ability to reduce social interactions and to 'stay home' is not distributed evenly in a society.[17,18] The spread of the virus in phase 2 is shaped by the extent to which individuals manage to reduce their social contacts. In general, white collar activities can be moved to a home office, while other workers still need to commute to their workplace and work if their employer does not lock down the workplace. Poorer people find social distancing more challenging than richer people, having less access to resources to shield them from the economically damaging effect of the lockdown. Regardless of how and where the virus had spread first in the initial phase of the pandemic, in phase 2 the virus is likely to become a poor man's disease. In fact, we find that in the second phase of the pandemic, poorer and more socially deprived districts start to have higher than average Covid-19 mortality rates.

Methods

The transition from phase 1 to phase 2 is a smooth process rather than a hard cut, as this depends on when people start consciously changing their behaviour and some do so earlier than others. Still, a definite break comes with the lockdown. The first German states to go into lockdown were Bavaria and the Saarland. Their curfew begun on 21 March; one day later the whole of Germany followed. Hartl et al.[19] find that "confirmed Covid-19 cases in Germany grew at a daily rate of 26.7% until 19 March. From March 20 onwards, the growth rate drops by half to 13.8%, which is in line with the lagged impact of the policies implemented by the German administration on 13 March and implies a doubling of confirmed cases every 5.35 days. Before 20 March, cases doubled every 2.93 days."

Ideally, we would test our first prediction with data on cases from late March or early April, since it takes roughly a week from the implementation to the effectiveness of policy measures on infection rates. Unfortunately, the first date at which we were able to capture the full distribution of confirmed infections and deaths across all German districts is 13 April, with data sourced from the website of the Robert Koch Institute. Whilst clearly introducing measurement error as overlapping with the second phase of the pandemic, the strong path dependency of any pandemic means that the cumulative number of infections on 13 April will be sufficiently strongly correlated with the cumulative number of infections around 30 March, which would have been the ideal date. Since it takes more time for people to die from Covid-19, 13 April may represent close to the ideal end period for phase 1 for our analysis of fatalities.

To study our second prediction, we take as our second dependent variable new infections and fatalities that happened in the second period between 14 April and 19 May. These cases occurred after people had time to adjust to the by now fully known risks and the lockdown had been imposed. A major relaxation of the lockdown took place on 19 May such that one can take 19 May as the end of phase 2 of the pandemic. We divide cases and fatalities by a district's population size in 10,000 people. Consequently, the dependent variables in our regressions represent cumulative cases or fatalities per capita and cumulative new infections or new fatalities per capita. We estimate our regression models with ordinary least squares and robust standard errors.

As our measure of wealth of a district we include the average income subject to income tax in thousands of Euro. We also control for the share of the workforce that is university-educated. This variable is a proxy for the share of the population that can work from a home office and is correlated at r = 0.85 with an index of working from home potential calculated by Alipour et al.[20] To measure social deprivation we include the unemployment rate.

Average taxable income is highly negatively correlated with the unemployment rate at r = -0.58, which is why we include average taxable income and the unemployment rate only in separate regressions.

As two proxy variables to account for the way in which the virus first entered Germany and spread initially we include the latitude location of a district and the share of its population that is Catholic. The former accounts for the ease by which residents could drive to the Alps for ski tourism, whilst the latter accounts for the greater popularity of carnival as potential super-spreader events in predominantly Catholic districts.[12,13] A further way in which we account for the path dependency of the pandemic is by including the cumulative number of cases on 13 April into the regressions with cumulative new infections between 14 April and 19 May as dependent variable. The correlation between cumulative infections on 13 April and cumulative new infections between 14 April and 19 May is 0.59, which predominantly results from a strong path dependency in infections.

In addition, we include dummy variables for whether a district is predominantly urban and is geographically in an extremely remote location. The virus spreads more easily in more densely populated urban habitats[21,22] and while extreme remoteness is often seen as a costly locational disadvantage,[23,24] it partly protects the local population from infections as there will be less exchange with people from the outside. All data for the explanatory variables are sourced from regional databases of the German statistical offices.

Results

Table 1 reports results for average taxable income as the central socio-economic explanatory variables, table 2 does the same for the unemployment rate. In the first phase, average taxable income is positively associated with cumulative cases measured on 13 April at the district level. Model 1 suggests that a district that has an average income of 10,000 Euros higher than the mean income of German districts has 6.3 [95% C.I.: 3.0 to 9.6] additional cases per 10,000 people relative to the district mean. This is a substantively important effect given that the average number of known cumulative cases of German districts on April 13 stood at 14.9 with a standard deviation of 12.3.

In phase 2 we regress the cumulative number of known infections between 14 April and 19 May on the same set of variables. During this period, the mean of cumulative new infections per 10,000 people is 6.3 [s.d.= 5.7]. In this period the association between cumulative cases and average taxable income of a district becomes negative but is not statistically significant (model 2). Our results also suggest that mortality rates are lower in richer and therefore higher in poorer districts in phase 2 (model 4). Taxable income thus shows a negative association with cumulative cases in phase 1 but not in phase 2, demonstrating that the pandemic increasingly affects poorer districts too even if, as in Germany, the pandemic started in richer districts. Likewise, average income has no systematic association with cumulative deaths in phase 1 but becomes negatively associated with deaths in phase 2.

Insert table 1 about here

The opposite pattern to what we find for taxable income holds for the unemployment rate (table 2). Districts with a higher unemployment rate reported lower cumulative cases in phase 1 (model 5) and higher cumulative deaths in phase 2 (model 8). Hence, regardless of the socio-economic indicator we use, we find that in phase 2 the pandemic increasingly affects poorer and more socially deprived districts too in terms of cumulative infections and actually affects them more in terms of cumulative deaths.

Insert table 2 about here

There are thus interesting differences between our analysis of infection rates and mortality rates. In phase 1, the population of poorer and more socially deprived districts is less likely to get infected with Sars-CoV-2 than the population in richer and less deprived districts but there are no statistically significant mortality differences between these districts. In phase 2 and controlling for path dependency, the population of poorer and more socially deprived districts is at least equally likely to get infected, but the probability to die from Covid-19 is statistically significantly higher. In Germany at least, Covid-19 increasingly becomes a disease of the poor after lockdown – arguably, because the rich find it easier to follow the rules of social distancing, a result that is consistent with Harris.[6]

Discussion

We studied the relationship between socio-economic factors and the Covid-19 pandemic in Germany, distinguishing between two phases and analysing both infections and fatalities. We have shown that the population of poorer districts is not necessarily more likely to get infected with Sars-CoV-2. In Germany during the first phase of the pandemic, poorer districts and districts with a higher unemployment rate had fewer infection rates. Due to the inherent limitations of an ecological study, our analysis at the district level cannot conclusively identify the causal mechanisms. Yet, it seems likely that the distribution of the virus during the first phase of the pandemic in Germany has been largely influenced by ski tourism. Districts geographically closer to the Alps are relatively wealthy and have little social deprivation by German standards. As a consequence, the pandemic started in Germany predominantly as a rich man's disease. In this initial phase, mortality rates in poorer and more socially deprived districts were not higher though poorer and more socially deprived people tend to have more co-morbidities, which increase Covid-19 mortality.[25]

Since lockdown, however, and controlling for the strong path dependency in the spread of the disease, poorer and more socially deprived districts no longer report lower infection rates and deaths become increasingly concentrated in these districts. The gap in infection rates between richer and poorer districts closes and a gap in mortality rates begins to open with poorer districts now having higher than average mortality rates. The same applies if we employ the unemployment rate as a measure of social deprivation. Covid-19 is slowly becoming a poor man's disease. An ecological analysis cannot trace the causal mechanism but it is very likely that more people in richer districts as well as in districts with a higher share of university educated employees could work from home and afford to behave in a socially distanced way than people in poorer and more socially deprived districts.[26] This is entirely consistent with studies from other countries showing a higher mortality rate among individuals with lower socio-economic status, with the higher prevalence of co-morbidities in such individuals one of the likely causal mechanisms.[25] The recent emergence of hotspots in slaughterhouses in the districts of Gütersloh and Oldenburg indicate that the pandemic has reached the very poor: temporary migrant workers from Bulgaria and Romania.

The subtle difference in results between the 'infections model' and the 'deaths model' is particularly interesting. These results lend indirect empirical support to previous findings suggesting that the case fatality rate, that is, the number of deaths per known infected people, is higher in poorer districts.[27] Sorci et al.[28] have used a very different research design to ours, regressing the case fatality rate on a battery of explanatory variables including some socioeconomic factors, whereas our estimates have the population fatality rate as the dependent variable. For their sample they find that higher than average per capita income is weakly associated with lower than average fatality rate. Our results are consistent with their findings in both phases: in phase 1 poorer and more socially deprived districts combine a low infection rate with an average death rate, in phase 2 poorer and more socially deprived districts combine an average infection rate with a higher than average death rate. We suspect that this finding results from the higher prevalence of comorbidities in relatively poor districts in Germany and with variations in the ability to follow social distancing rules. Covid-19 magnifies the effect of behavioural differences on health outcomes, but does not in itself discriminate between rich and poor. All viruses spread through social interactions and we should not be surprised that pandemics crystallize the socio-economic determinants of social interactions and the socio-economic constraints on the ability to follow social distancing rules.

Conflict of interest

None declared.

Funding

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Data availability

The replication data and do-file will be made available on dataverse.org upon publication.

Key points

• Whether Covid-19 predominantly affects poorer or richer neighbourhoods depends on how the virus first entered a society. In Germany, this was predominantly via tourists returning from ski holidays in the Alps.

• Wealthier districts initially saw higher and more socially deprived districts recorded lower Covid-19 infection rates during the first phase of the pandemic in which the virus could spread largely unhampered by social distancing measures.

• Lockdown policies exert a strong effect on the social stratification of Covid-19. Once governments implement a lockdown, the ability to socially distance oneself from others determines the individual risk of an infection and at the district level Covid-19 increasingly becomes a disease of poorer and socially deprived districts.

• Controlling for the path dependency of infections, wealthier districts recorded lower and socially more deprived districts recorded higher Covid-19 mortality rates during the second phase of the pandemic in which lockdown was in place.

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Table 1. Ordinary least squares regression analysis of the evolving relationship between taxable income per capita and C-19 cases and deaths per capita.

Dependent variable:	Model 1 (Cumulative cases per capita 13/04)	Model 2 (New cum. infections per capita 14/04 to 17/05)	Model 3 (Cumulative deaths per capita 13/04)	Model 4 (New cumulative deaths per capita 14/04 to 17/05)
Cumulative cases per capita 13 April		0.265**		0.0600**
		(0.176 - 0.355)		(0.0437 - 0.0764)
Taxable income	0.632**	-0.135	0.00519	-0.0336**
	(0.302 - 0.962)	(-0.299 - 0.0294)	(-0.0151 - 0.0255)	(-0.0574 - -0.00993)
% workforce university-educated	-0.0988	-0.141*	-0.00325	-0.0122
	(-0.306 - 0.108)	(-0.255 - -0.0262)	(-0.0156 - 0.00913)	(-0.0263 - 0.00186)
Urban district dummy	-0.917	1.012	-0.0388	0.0410
	(-3.152 - 1.317)	(-0.148 - 2.171)	(-0.169 - 0.0911)	(-0.110 - 0.192)
Very remote district dummy	-1.228	-1.774**	-0.0517	-0.155**
	(-3.480 - 1.025)	(-2.768 - -0.781)	(-0.188 - 0.0844)	(-0.256 - -0.0538)
Latitude	-1.866**	-0.421*	-0.0516*	-0.00205
	(-2.585 - -1.146)	(-0.814 - -0.0273)	(-0.0957 - -0.00742)	(-0.0533 - 0.0492)
Population share catholic	0.133**	-0.0146	0.00545	-0.00268
	(0.0444 - 0.221)	(-0.0446 - 0.0153)	(-0.000399 - 0.0113)	(-0.00615 - 0.000790)
Constant	95.16**	27.56*	2.776*	0.678
	(57.25 - 133.1)	(5.757 - 49.37)	(0.380 - 5.171)	(-2.025 - 3.382)
Observations (local districts)	401	401	401	401
R-squared	0.340	0.374	0.114	0.575

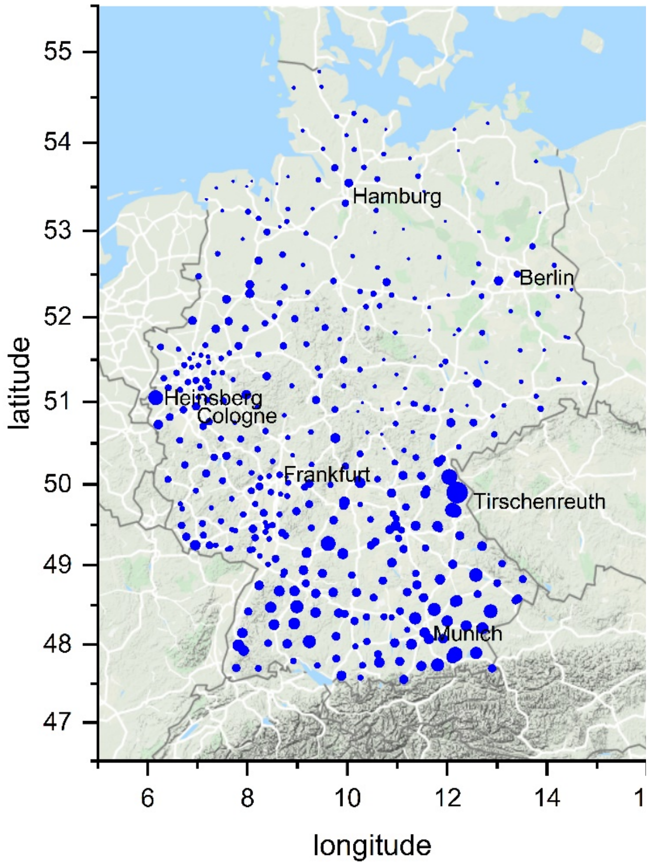
Note: 95% confidence interval in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2. Ordinary least squares regression analysis of the evolving relationship between the unemployment rate and C-19 cases and deaths per capita.

Dependent variable:	Model 5 (Cumulative cases per capita 13/04)	Model 6 (New cum. infections per capita 14/04 to 17/05)	Model 7 (Cumulative deaths per capita 13/04)	Model 8 (New cumulative deaths per capita 14/04 to 17/05)
Cumulative cases per capita 13 April		0.264**		0.0594**
		(0.176 - 0.351)		(0.0428 - 0.0760)
Unemployment rate	-0.899**	0.155	-0.0199	0.0336*
	(-1.259 - -0.540)	(-0.0924 - 0.403)	(-0.0411 - 0.00125)	(0.00144 - 0.0657)
% workforce university-educated	0.0735	-0.175**	-0.000986	-0.0204**
	(-0.126 - 0.273)	(-0.290 - -0.0595)	(-0.0138 - 0.0118)	(-0.0349 - -0.00592)
Urban district dummy	0.355	0.765	-0.0197	-0.0170
	(-1.987 - 2.696)	(-0.400 - 1.930)	(-0.161 - 0.121)	(-0.175 - 0.141)
Very remote district dummy	-1.012	-1.775**	-0.0331	-0.149**
	(-3.407 - 1.382)	(-2.805 - -0.745)	(-0.166 - 0.100)	(-0.251 - -0.0462)
Latitude	-1.679**	-0.443*	-0.0427	-0.00491
	(-2.435 - -0.924)	(-0.826 - -0.0604)	(-0.0892 - 0.00387)	(-0.0565 - 0.0467)
Population share catholic	0.138**	-0.0162	0.00526	-0.00316
	(0.0541 - 0.223)	(-0.0481 - 0.0156)	(-0.000295 - 0.0108)	(-0.00673 - 0.000416)
Constant	98.99**	26.05*	2.491	0.187
	(58.43 - 139.5)	(5.394 - 46.71)	(-0.0154 - 4.997)	(-2.646 - 3.020)
Observations (local districts)	401	401	401	401
R-squared	0.337	0.372	0.116	0.569

Note: 95% confidence intervals in parentheses. ** $p<0.01$, * $p<0.05$

Map 1: Distribution of Cumulative Known Sars-CoV-2 Infections Per Capita, up to 13 April



Map 2: Distribution of Cumulative Known Sars-CoV-2 New Infections Per Capita, 14 April to 17 May