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Social capital and geographic variation in the incidence of COVID-19: An ecological study

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Abstract

Background: The new behavioural norms needed to reduce the spread of COVID-19 are likely scaffolded by social capital. Research on social capital and COVID-19 has yielded mixed results, with some studies finding it to be protective while others identify it as a risk factor. We examined the association between social capital and COVID-19 at a finer spatial scale than previous research, and examined changes in the relationship over the course of the pandemic.

Methods: Routine COVID-19 surveillance data from Wales were linked to estimates of social capital at a small area level. Generalised linear mixed effects models predicting COVID-19 case rates across areas using social capital estimates and possible confounding variables were fitted to the data. A moving window version of the analysis explored whether this relationship varied across time.

Results: Areas with higher levels of social capital had lower rates of COVID-19 (rate ratio for trust=.94, 95%CI=.92-.96, rate ratio for belonging=.94, 95%CI=.92-.96). These associations were strongest during periods of lockdown, with evidence that social capital was less protective, and potentially even a risk factor, during periods when restrictions were eased. Trust, but not belonging, remained protective after adjusting for deprivation, population density, ethnicity, and proportion population aged over 65 years.

Conclusions: Social capital is an important public health resource, which should be considered in future pandemic preparedness. Its importance may be greatest during times when social activity is most restricted.

What is already known on this subject?

Area-level social capital has received wide attention as a social determinant of health in a number of settings. It is generally protective, but can be a risk factor under some circumstances. Work on the relationship between social capital and COVID-19 outcomes, however, has been mixed.

What this study adds?

Area-level social capital is, in aggregate, associated with lower COVID-19 infection rates, but this association is not consistent across time. Social capital was most protective during periods of 'lockdown' but less protective, and sometimes even a risk factor, during periods of less stringent restrictions.

Governments' public health responses to COVID-19 are dependent on creating and maintaining new social norms to minimise viral spread. Acceptance of these new norms, however, is likely underpinned by more fundamental values. One conceptual framework for understanding these values is that of social capital.

Social capital refers to resources embedded within social networks[1,2]. The construct has been extensively applied to social epidemiology[3,4], where it has generally been found to be protective in a variety of health contexts[5,6]. However, especially in the Bourdieusian tradition, social capital is a form of *capital* and should not be mistaken for a universal public good. A growing body of work shows that social capital can also be a risk factor for health problems under certain circumstances[7,8].

In the context of COVID-19, the networks that social capital reflect are both the basis of the collective action needed to limit the person-to-person spread of the virus and the vectors along which the virus spreads. Thus it is plausible that social capital could be a risk or a protective factor.

The emerging evidence on social capital and COVID-19 has yielded mixed results. Makridis and Wu[9] and Borgonovi *et al.*[10] run similar analyses on the association between social capital and COVID-19 cases and deaths, across US counties, finding social capital to be protective. Similarly Bartscher *et al.*[11] found a protective association between electoral turnout, a proxy for social capital, and case rates in subnational regions in Europe. Conversely, Elgar *et al.*[12] examined the association between different facets of social capital and the growth of COVID-19 mortality across 84 countries. Some facets were protective (civic engagement and confidence in state institutions), while others were associated with worse outcomes (generalised trust,

group affiliations). In another between-countries analysis, Min[13] found that social trust was associated with infections peaking faster.

One pattern in these results is that studies finding a protective effect of social capital looked at sub-national units, while studies finding adverse associations with social capital made international comparisons. The dependence of contextual health effects on the spatial scale of analysis is a fundamental problem[14], but here there are particular reasons to expect differences. Analyses on higher spatial scales may combine effects of 'traditional' social capital mechanisms with those of governmental policy responses. Given that governmental responses may be downstream of citizens' values, such policy differences may indeed be a distal causal outcome of differences in social capital, but there is value in trying to disentangle these associations. This necessitates looking at spatial scales below the lowest level of geography where policy is made. The smallest spatial scale of the studies above is the US county level, which does not meet these criteria.

A second consideration is that the existing literature focuses primarily on the first months of the pandemic. It is plausible that the association between social capital and COVID-19 spread is not consistent over time, and may manifest differently as behavioural interventions change over time.

The present study looks at the association between social capital and COVID-19 spread on a finer spatial scale than previously: the middle super output area (MSOA) in Wales. MSOAs exist below the smallest unit of administrative geography in Wales, and are thus ideal for our purposes.

Methods

Ethical approval

This project was approved by Bangor University School of Psychology ethics committee. Data provided by Public Health Wales were a collated version of those publicly available via their COVID-19 dashboard[15].

Data

The outcome data were the number of cases of COVID-19 in Wales, confirmed by polymerase chain reaction testing and reported to Public Health Wales through routine daily surveillance established at the start of the pandemic, stratified by week and MSOA of residence. MSOAs are a unit of census geography with populations of ~8000, developed using UK Census data to for disclosure control and standardising the reporting of small-area statistics, with 410 in Wales. MSOAs are designed to reflect the structure of underlying communities (as opposed to *e.g.* ZIP codes). The period of data used was the week beginning 13th April 2020 until the week starting 11th January 2021.

The main exposures used were modelled estimates of generalised trust and sense of belonging at MSOA-level. These estimates were derived using multi-level regression with post-stratification as part of a previous study[16] using the National Survey for Wales 2016/17 (N= 10,486). Estimates available to download[17].

A full description of how these estimates were derived can be found elsewhere, but to summarise: Trust was measured using the item: *'Would you say that most people can be trusted? Please answer on a scale from nought to 10 where nought means that in general you do not trust any other person and 10 that you feel most people can be trusted.'* Data

were dichotomised so 0–4 were categorised as 0 and 5–10 as 1. Belonging was measured using the item *'I belong to my local area'*. Responses were dichotomised so the responses 'strongly disagree' or 'tend to disagree' were coded as 0 and the responses 'strongly agree', 'tend to agree', or 'neither agree nor disagree' were coded as 1.

Generalised mixed effects models were fitted to these data with fixed effects of population density and the proportion of residents with no formal qualifications for trust and measures of population turnover and unemployment for belonging. Both models had identical random effect structure: random intercepts of age band and sex, with random slopes for national identity and ability to speak Welsh by local authority (an administrative unit which MSOAs are nested within, N=22). The resulting coefficients were post-stratified using 2011 census data to derive estimates of the two measures of social capital in each MSOA.

Adjusted models (see below), used data on the proportion of residents in each MSOA on low income-related benefits, from the Welsh Index of Multiple Deprivation[18]; and population density, proportion of residents aged 65 or older, percent identifying their ethnicity as 'White Welsh/English/Scottish/Northern Irish/British' from the 2011 UK Census[19]. These variables were selected as factors associated with both COVID-19[20,21] and social capital[22,23] in other studies, and thus potential for confounding.

Analyses

Generalised linear mixed effects models with Poisson log-link, implemented in the glmmTMB package[24] for R[25], were fitted to case count data, stratified by MSOA and week. All models contained population aged 3+ as an offset, random intercepts of MSOA,

nested within local authority (410 levels, nested within 22 local authorities), and random intercepts of week (40 levels). Two models were fitted for each of the two measures of social capital: an unadjusted model with area-level trust/belonging (z-scored) as the only fixed effect, and an adjusted model with trust/belonging and four confounding variables: percentage of residents on income support, population density, percentage of residents aged 65+, and percentage of residents reporting White Welsh/English/Scottish/Northern Irish/British ethnicity as fixed effects (all z-scored).

Moving window analyses were run to visualise how the relationship varied across time. Models were fitted on six-week blocks of data, modelling cases as a function of social capital, with a random intercept of MSOA, nested within local authority, and an offset for population. The six-week window was moved across the data, one week at a time and the coefficients and confidence intervals were plotted as a function of time to identify temporal variability in the relationship. Unadjusted and adjusted versions, as above, were fitted for trust and belonging

Results

Figure 1 shows the distribution of confirmed COVID-19 cases in Wales, along with estimates of trust and belonging. High infection rates are seen in the south, in a belt from the south Wales valleys toward the city of Swansea, and, to a lesser extent in the north-eastern counties of Wrexham and Flintshire. Likewise, the social capital measures were lowest in the valleys, the major cities of the south, Wrexham in the north-east, and the north-east coast. These distributions reflect the social geography of Wales. The valleys are a post-industrial region with high rates of poverty and poor health [26], while Welsh-speaking communities in the west have better health [27].

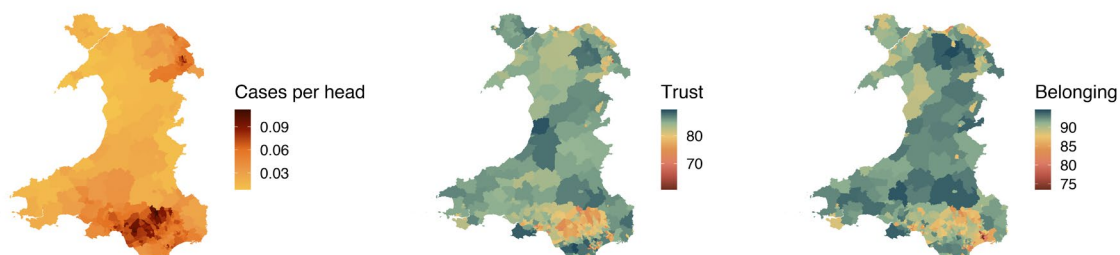


Figure 1 Geographical distributions of confirmed cases of COVID-19 (left), trust (centre), and belonging (right) by MSA. Contains public sector information licensed under the Open Government Licence v3.0. Colour palettes from MetBrewer R package[29].

COVID-19 rates decline with increasing social capital. Figure 2 shows overall recorded case rates for each MSA, plotted against estimates of trust (left) and belonging (right).

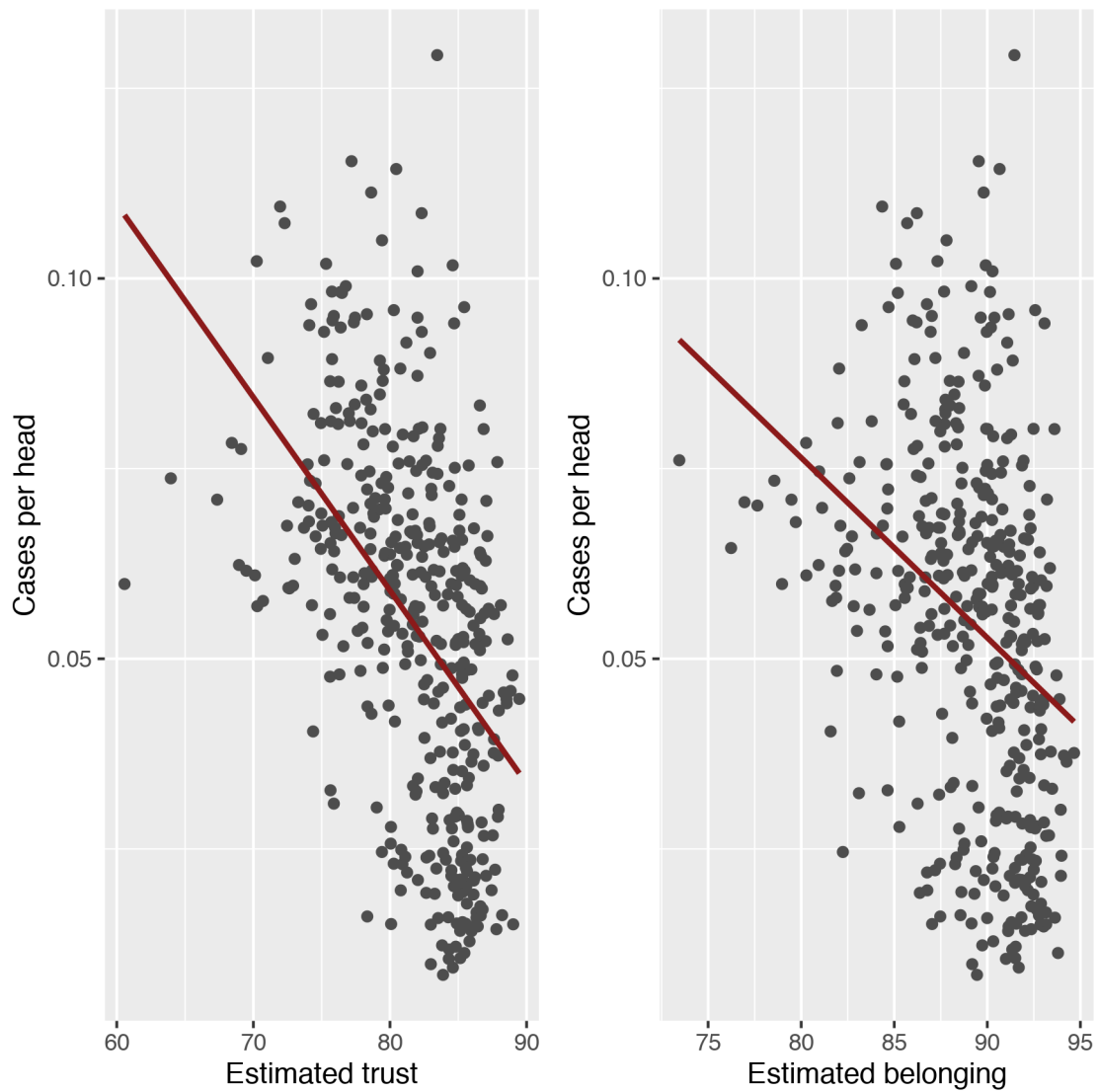


Figure 2. Scatterplots of trust (left) and belonging (right) against total number of confirmed cases of COVID-19 by MSA.

This is confirmed by the mixed effects models. In the unadjusted models, a ~6% reduction in cases was shown for every standard deviation increase in trust (rate ratio (RR)=.94, RR_{95%CI}=.92-.96) or belonging (RR=.94, RR_{95%CI}=.92-.96).

Trust remained protective (RR=.88, RR_{95%CI}=.82-.93) after adjusting for the identified confounds. Belonging, however, did not survive adjustment (RR=.99, RR_{95%CI}=.94-1.05).

Term	Unadjusted model			Adjusted model			
	RR	2.5%	97.5%	RR	2.5%	97.5%	
Trust Models	Trust (z-scored)	0.941	0.921	0.961	0.876	0.822	0.933
	Income deprivation (z-scored)				0.928	0.879	0.980
	Population density (z-scored)				0.964	0.931	0.998
	Percent 65+ (z-scored)				0.966	0.942	0.991
	Percent White Welsh/British/ English/Scottish/NI (z-scored)				0.964	0.935	0.994
Belonging Models	Belonging (z-scored)	0.941	0.919	0.963	0.9902	0.9373	1.0461
	Income deprivation (z-scored)				1.0245	0.9835	1.0673
	Population density (z-scored)				1.0041	0.9749	1.0341
	Percent 65+ (z-scored)				0.9699	0.9431	0.9976
	Percent White Welsh/British/ English/Scottish/NI (z-scored)				0.9777	0.9457	1.0108

Table 1. Rate ratios, with 95% confidence intervals, for all terms in the four models to the overall data.

Figure 3 shows results of the moving window analyses. In the unadjusted models, trust was a fairly consistent protective factor, except during the relaxation of lockdown rules over the summer. This pattern was even clearer for belonging, which was a strong protective factor during lockdowns but not at other times.

In the adjusted models, the protective status of both constructs was generally attenuated, especially earlier in the pandemic. Later on, trust was a fairly consistent

protective factor while belonging was a *risk* factor during the relaxation of rules following the autumn ‘firebreak’ lockdown (23rd October to 9th November 2020).

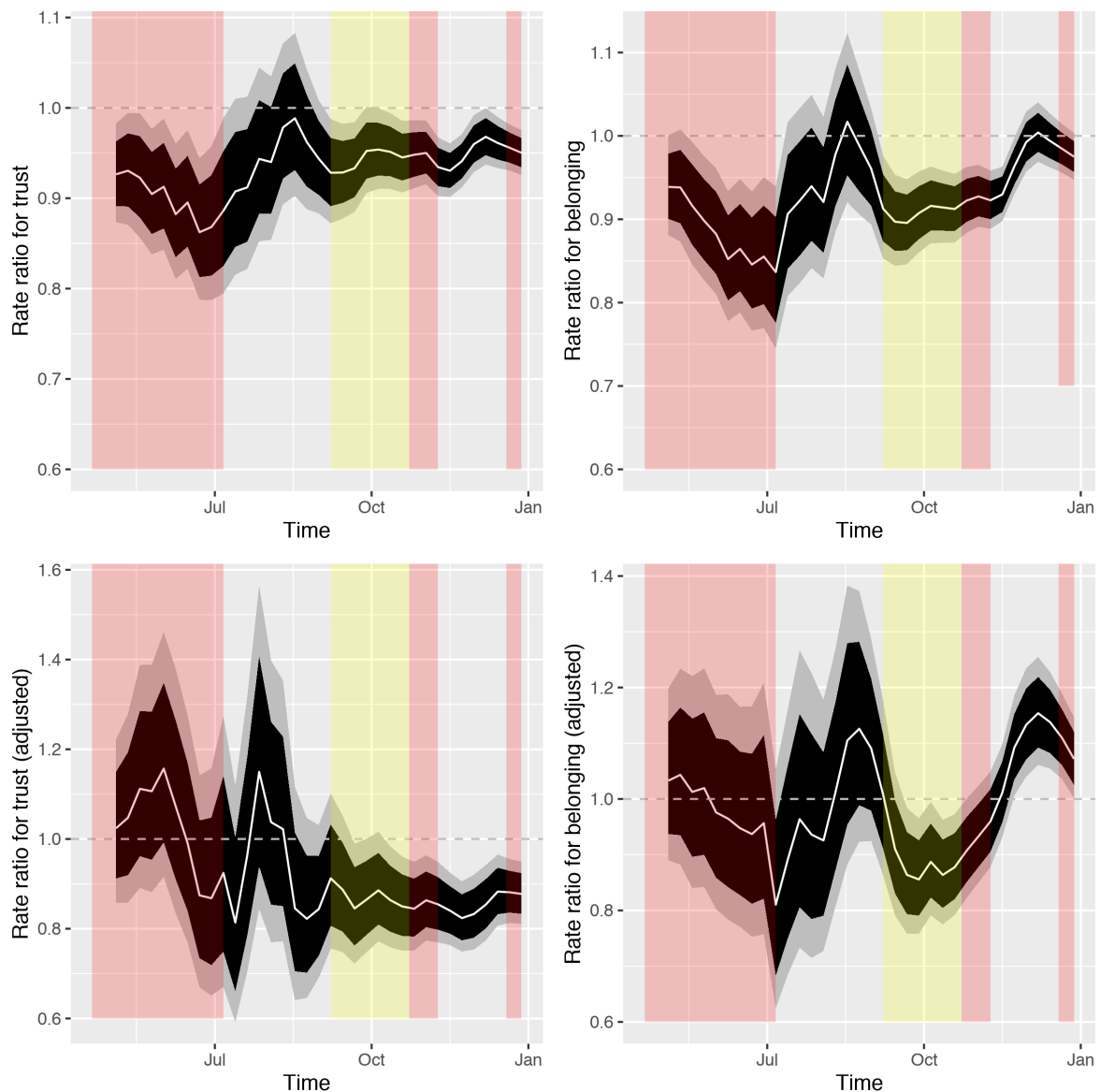


Figure 3 – Moving average analyses showing changing association between social capital and COVID-19 rates, with trust on the left-hand column and belonging on the right, and unadjusted models on the top row and adjusted models on the bottom. White lines represent point estimates, solid black areas represent 80% confidence intervals and transparent black areas represent 95% confidence intervals. Periods shaded red represent periods of national lockdown; periods shaded yellow represent periods when some areas were under ‘local lockdowns’. Defining the end of the first lockdown is difficult as rules were gradually relaxed. Here, we have used the date when ‘stay local’ restrictions were lifted (6th July 2020).

Discussion

We used routine surveillance data to investigate the association between social capital and COVID-19 rates at a finer-grained level of geography than previous work. Overall, as with previous within-country studies, we find social capital to be protective. However, we also present exploratory analyses of temporal variability in this relationship finding social capital to be more protective during lockdowns than other periods, suggesting that social capital might facilitate the collective action required during lockdowns. Interestingly, sense of belonging became a risk factor (after adjustment for confounds) during the more relaxed period in the autumn, supporting the idea that strong community ties can have both positive and negative effects during a pandemic.

These results echo previous findings. Like other within-country studies [28–30], we find evidence that social capital scaffolded lockdowns, but also replicate studies finding that higher belonging can lead to faster spread[12]. Indeed, these results are a microcosm for the literature on social capital and health in general: social capital is generally a health asset, but is unevenly distributed and can contribute to poorer health outcomes under certain circumstances[7,8].

Our results do not identify specific mechanisms, but we propose several possibilities. One is that social trust and belonging are necessary for the social solidarity to make the shared sacrifices of lockdowns. The first lockdown featured the emergence of conspicuous displays of social solidarity, such as the singing in Italian cities[31] and ‘Clap for Carers’ in several European countries[32]. The value of such symbolic gestures was the subject of debate in the UK[33], but these novel rituals can be seen as a way to

signal and spread adherence to new norms. Secondly, these values may be a proxy for institutional trust, which has been shown to be related to the spread of COVID-19[12], and likely also scaffolds compliance with public health guidance. On the potentially negative effects of belonging outside of lockdowns, it is plausible that high belonging communities have greater rates of social contact outside of lockdowns, driving spread of the virus.

Finally, Wales is an interesting context for this research. Much of the population live in former coalfield regions, which have been linked, paradoxically, to both lower social trust[34] and enduringly greater rates of trade union membership[35], suggesting norms of social solidarity.

Strengths

This study is novel in examining associations between social capital and COVID-19 infection rates at a finer spatial scale than previously. This is important because existing studies may have conflated bottom-up social capital mechanisms with the policy response of governments at national and local levels. The use of multi-level regression with post-stratification to estimate social capital allows this finer spatial scale, reducing the measurement error associated with simple disaggregation of survey data by small area that is common in studies of ecological social capital[16].

Limitations

Several caveats should be highlighted. Firstly, the analysis is observational and causation cannot be established. The estimates of social capital pre-date the pandemic,

so there is no possibility of reverse causation, but social capital may be correlated with causal risk factors, rather than being causal itself. The socioeconomically deprived areas where social capital is estimated to be low may have other risk factors such as residents who cannot work from home or greater dependence on public transport. The adjusted model may have accounted for some confounding, but residual confounding is likely.

Secondly, as an ecological study, the analysis faces issues such as the modifiable areal unit problem. It is debateable the extent to which the ecological fallacy is also an issue: social capital can be measured on the individual level, but as a social property it also has a distinct meaning on the area level which is relevant in the context of infectious disease, where risk is socialised. Furthermore, public health interventions are often implemented on the area level. Furthermore, as MSOAs have a minimum population to avoid disclosing identities, rural MSOAs are geographically large. It is plausible that rural MSOAs amalgamate distinct areas to a greater extent than urban MSOAs.

Thirdly, data represent cases confirmed by routine testing, presenting several issues. Social capital may be a determinant of whether people present for testing. The lack of economic support to people self-isolating in the UK has been criticised[36], and willingness to self-isolate may be lower in areas of low social capital, either due to social norms, or structural factors like insecure work. A separate issue is that testing capacity increased markedly during the study period and testing policy changed. Thus confirmed cases represent a smaller proportion of true cases earlier in the study. It is unclear what effect this changing mapping between true incidence and observed incidence may have had on our results. Another option would have been to analyse COVID-19 deaths, which

may be recorded more consistently over the course of the pandemic. However, dividing these among small geographic areas would have presented issues of statistical power.

Fourthly, the moving window analysis was exploratory, designed to look at heterogeneity in the relationship over time, rather than an explicit test of whether social capital is protective because of its facilitation of lockdown behaviours. It may be that the lower case rates following lockdowns biased RRs towards the null, and the apparent relationship seen is artefactual. That said, the increase in testing described above means that the number of confirmed cases is less confounded with lockdown across the period of the study than one might imagine.

Fifthly, social capital is a multifaceted construct and our study only looks at two aspects of it, both of which fall under the umbrella of cognitive social capital. Network or structural measures of social capital may have had different associations, indeed other work has found measures of civic engagement and structural capital to have been protective[12,28]. Furthermore, the estimates were generated using survey data from 2016/17 and it is possible that the geography of social capital has changed since. There are advantages to using pre-existing estimates, as they maximise comparability with other published work and minimise the risk of p-hacking. The 2016/17 survey was also the only year where both belonging and trust were available in the same survey

Finally, there is a risk that this study falls into victim-blaming, where high case rates result from unwillingness to follow the rules. Indeed, the concept of social capital has long been criticised as a peculiarly individualist conception of communitarianism[37]. Bourdieu's conception of social capital[1], although less common in social epidemiology

than Putnam's[2], is more cynical, putting it alongside economic capital as an unequally distributed resource. We hope our findings are viewed in the tradition of health inequities, rather than as chiding of disadvantaged communities for not sticking to the rules.

Future work

This study used an ecological design, but future work would benefit from combining individual and area-level data to explore how individual and contextual social capital interact to determine outcomes. Furthermore, geospatial statistical techniques, such as geographically-weighted regression, allow analysis of how statistical relationships vary over space, which might be a useful approach.

Implications

Our work underscores the importance of social values like trust and belonging to the successful implementation of public health measures. Ensuring public trust in public health measures has been widely recognised as key to the fight against COVID-19 and future pandemics[38], but the work of building trust and social capital should also be seen as a long-term project to prepare for future public health emergencies. Indeed social capital has also been shown to be part of community resilience in the wake of natural disasters[5,39]. Thus, 'third places' like pubs, libraries, and community centres[40] which foster social capital may be important health assets and their decline should be a cause for concern on public health grounds, as well as in purely civic terms.

To conclude, we examined the association between area-level social capital and COVID-19 case rates on a finer-grained scale than previously. It appeared that social capital

was mainly protective during periods of lockdown, with sense of belonging becoming a risk factor during periods of more relaxed rules. The results contribute to our understanding of the complex relationship between social capital and health, both in the specific context of COVID-19 and more broadly. Building social capital and increasing community resilience should be an essential component of future pandemic preparedness.

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