Contributing factors and mitigation strategies for areas of enduring COVID-19 prevalence

Report 1 – Drivers and regional variations

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The PROTECT COVID-19 National Core Study on transmission and environment

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The PROTECT COVID-19 National Core Study on transmission and environment is a UK-wide research programme improving our understanding of how SARS-CoV-2 (the virus that causes COVID-19) is transmitted from person to person, and how this varies in different settings and environments. This improved understanding is enabling more effective measures to reduce transmission – saving lives and getting society back towards 'normal'.

This report investigates the key drivers of enduring prevalence across areas of varying prevalence. UK local authorities that experience sustained high levels of COVID-19 are termed areas of enduring prevalence (AEP) according to UK Scientific Advisory Group for Emergencies (SAGE) in 2021. This was a mixed methods study, involving qualitative interviews and the collection and analysis of data on a range of indicators.

The research suggests that existing health inequalities influence the wider picture of prevalence rates of COVID-19. Further research is needed, ideally at ward/SOA level, on how these factors combine to predict transmission and how this varies between different areas, and on the relative importance of each of these factors. Additionally, the researchers recommend assessing the role of mass movements of individuals into and out of areas of high prevalence and considering actions that can be taken to tackle modifiable risk factors for the enduring prevalence of COVID-19.

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Report 1 – Drivers and regional variations

Authors

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Abstract

Background. Variations in enduring prevalence of COVID-19 have been identified, and several local UK authority areas have experienced sustained high levels of the virus. This report (Report 1) examines key drivers of prevalence, and variations between local authority areas. A second report (Report 2) examines the mitigation strategies implemented by Directors of Public Health across England during the course of the pandemic.

Methods. An analysis of the differences between areas of enduring prevalence of COVID-19 and comparison areas on a range of indicators was conducted. Data on deprivation, ethnicity, overcrowded households, and factors related to employment were collected for the local authority areas included in the research, to reflect some of the themes that were emerging from interviews with the Directors of Public Health and from the literature review. Semi-structured interviews were undertaken with 19 Directors of Public Health across England, between July and November 2021. Nine of the 19 interviews were in areas identified by Public Health England as spending the highest number of days in an epidemic phase ('areas of enduring prevalence'), and ten were in 'comparison' areas that had fewer days of high community infection during the pandemic.

Results. The indicator data analysis revealed that the areas of enduring prevalence overall were more deprived, had significantly lower levels of employment and significantly higher proportions of people working in lower skilled occupations, had a higher proportion of people who lived in overcrowded housing, a higher proportion of people from ethnic minority backgrounds and lower vaccination rates than the comparison areas.

Directors of Public Health also identified high deprivation levels, overcrowded housing, and low vaccination rates as risk factors for enduring prevalence. Deprivation and employment were often jointly discussed as creating major barriers for people to self-isolate or work remotely. Not receiving sick pay, working on zero hours contracts or in insecure employment were identified as reasons for inability to self-isolate. There were strong similarities in the drivers of enduring prevalence described by the Directors of Public Health in areas of enduring prevalence and comparison areas. All participants asserted that there were differences in these factors between different wards or geographical areas within their local authority, and between different groups, including people from different age groups and ethnic backgrounds. Participants in comparison areas were more likely to identify travel in and out of the local authority area as a risk factor.

Conclusion. The research suggests that health existing health inequalities influence the wider picture of prevalence rates of COVID-19. Structural factors including deprivation, employment, and housing, converging with demographic factors including ethnicity and age, and vaccination rates, are key drivers of prevalence, and there are key differences in these drivers both within local authorities, and to a lesser extent, between AEP and CA. Further research is needed, ideally at ward/SOA level, on how these factors combine to predict transmission and how this varies between different areas, and on the relative importance of each of these factors

Executive Summary

Introduction

UK local authorities that experience sustained high levels of COVID-19 are termed areas of enduring prevalence (AEP) according to UK Scientific Advisory Group for Emergencies (SAGE) in 2021. AEP are those with the highest number of days spent in the epidemic phase between 1/3/20 and 28/2/21. The epidemic phase is characterised by a greater mean number of daily cases, higher variability, and a stronger correlation between case numbers across consecutive days. A local authority is assumed to be in the epidemic phase if the probability of epidemic exceeds 0.75 (Gov.uk, 2021). This report, Report 1, investigates the key drivers of enduring prevalence, across areas of varying prevalence. A separate paper, Report 2, describes the key mitigation strategies used by Directors of Public Health (DsPH) to reduce transmission of COVID-19.

Methods

This was a mixed methods study, involving qualitative interviews and the collection and analysis of data on a range of indicators. DsPH in the eleven local authorities identified by SAGE as areas of enduring prevalence (AEP) (Gov.uk, 2021; SAGE, 2021) were invited to take part in the research, and nine of these agreed. A set of comparison areas (CA) were selected, according to recommendations by Directors of Public Health (DsPH), the Association of Directors of Public Health (ADPH) and Public Health England (PHE). For two AEP, statistical neighbours with low prevalence were identified and these were also included as CAs. Statistical neighbours are defined as those that are similar in terms of levels of deprivation, whether urban or rural, and on populations of young, old, and ethnic minorities (PHE, 2019). DsPH in ten CA agreed to take part in the research. Local authorities have been anonymised for the purpose of this report.

Indicators were collected for the local authority areas included in the research, to allow further investigation of some of the themes that emerged from the DsPH interviews, and from the literature review. Indicator data collected included overcrowding, occupation and employment status. Indicators were gathered from readily available data sources at the Office for Health Improvement and Disparities (formerly Public Health England fingertips) and NOMIS (Official Labour Market Statistics, ONS).

Semi-structured interviews were conducted with 19 DsPH across England in areas of enduring prevalence and areas with lower prevalence. All interviews were around an hour in length and covered 15 questions, including questions about local mitigation measures and barriers to reducing prevalence rates locally. The interview schedule was devised based on existing literature and in collaboration with the project steering group (details on inside front page), PHE and ADPH. Interviews were conducted online via Zoom or TEAMS by two researchers who were experienced in qualitative research methods (AH and CL) between June and November 2021. Interviews were transcribed and thematically analysed using an iterative coding process (Braun and Clarke, 2006). The interviews were coded using NVivo, using a coding framework guided by the research questions and the topics raised by the participants during the interviews. Codes were iteratively adapted and restructured throughout the initial coding stage and as a result of discussions between the researchers throughout the coding process.

All transcripts were coded using the developed coding framework. The initial analysis provided a broad picture of the themes that were discussed across all included local authorities. Using these codes as a framework, a comparison of similarities and differences within AEP and CA was then conducted, using tabulations and counting of instances discussed by DsPH with regards to drivers of high, sustained COVID-19 prevalence. Finally, a 1:1 comparison of AEP and CA which are statistical neighbours was conducted. This analysis provided an opportunity for deeper exploration of reasons for differences in prevalence rates in similar areas.

Results

The indicators collected showed that there are higher levels of deprivation in AEP than in CA. The proportion of people aged over 16 from ethnic minority groups is higher, although not significantly higher, in the AEP than in CA and the national average. The percentage of people in overcrowded housing tends to be higher in the AEP than in CA, except for the London local authorities.

The AEP tend to have higher proportions of people working in manufacturing, wholesale and retail and in education, than the CA. The percentage of people in employment is significantly lower in AEP than in CA, and the proportion working in lower skilled occupation groups is significantly higher in the AEP than the CA. The proportion of the population with a second covid vaccination is generally much lower in AEP. Data on booster uptake was not available at the time of writing.

In the interviews, participants identified various factors associated with enduring prevalence, including high deprivation levels, overcrowded housing, and low vaccination rates, along with the impact of motivation and beliefs, as discussed further in Report 2. Deprivation and employment were often jointly discussed as creating major barriers for people to financially afford to self-isolate or to work remotely. Not receiving sick pay, working on zero hours contracts or in insecure employment were associated with inability to self-isolate. Across that there were differences in these factors between different wards or geographical areas within their local authority, and between different groups, including people from different age groups and ethnic backgrounds. Participants in the AEP were more likely to discuss the impact of structural factors such as the impact of lack of sick pay or work insecurity, and of overcrowded housing.

Conclusion

The research suggests that existing health inequalities influence the wider picture of prevalence rates of COVID-19. Structural factors including deprivation, employment, and housing, converging with demographic factors including ethnicity and age, and vaccination rates, are key drivers of prevalence, and there are key differences in these drivers both within local authorities, and to a lesser extent, between AEP and CA. Further research is needed, ideally at ward/SOA level, on how these factors combine to predict transmission and how this varies between different areas, and on the relative importance of each of these factors.

Recommendations

- Conduct further research on how multiple factors interact in predicting enduring prevalence and which are the most important factors. This might include research on the views and experiences of:
    - Employers and employees, and other members of the local partnerships required to work together to respond to workplace outbreaks of COVID-19
    - Key health and social care actors, including Directors of Adult Social Care
    - Community and voluntary organisations, and other ‘seldom heard’ groups
- Conduct analysis of the indicators included in the report at ward/super-output area (SOA) level for AEP and CA, to allow more detailed comparisons between areas of varying prevalence
- Assess the role of mass movements of individuals into and out of areas of high prevalence.
- Consider actions that can be taken to tackle modifiable risk factors for the enduring prevalence of COVID-19, such as addressing differences in people’s capabilities, opportunities, motivations and behaviours in response to vaccination and government guideline engagement in the short term. In the longer term, action is needed to address structural inequalities that disproportionately impact certain groups. Issues to address include house occupancy, nature of work and housing standards.

Contents

Main Report

List of abbreviations

ADPH:	Association of Directors of Public Health,	**LAs:**	Local authorities
AEP:	Areas of Enduring Prevalence	**PHE:**	Public Health England
CA:	Comparison area	**SAGE:**	Scientific Advisory Group for Emergencies
COMF:	Contain Outbreak Management Fund	**UKHSA:**	UK Health Security Agency
DsPH:	Directors of Public Health		

1. Introduction and background

UK local authorities that experience sustained high levels of COVID-19 are termed areas of enduring prevalence (AEP) according to UK Scientific Advisory Group for Emergencies (SAGE) in 2021. This paper (Report 1) describes the key drivers of enduring prevalence, and the key differences between the AEP and comparison groups. A separate paper (Report 2) describes the key strategies used by Directors of Public Health (DsPH) to reduce transmission of COVID-19.

Aims

The aims of the research are:

- To gain expert views and insight into what might be the main factors that cause regional disparities in COVID-19 infections and why certain places appear to have consistently relatively high prevalence of COVID-19 infections compared to other places.
- Undertake data analysis for areas that were often similar in terms of deprivation and population mix, but different in terms of the enduring prevalence of COVID-19 and look for other factors that might help to explain these differences.

Since the start of the SARS-CoV-2 pandemic in March 2020, there have been regional variations in community transmission rates throughout the UK (Challen et al., 2021; Liu, Tang, & Lam, 2021). Many different places have been reported to have highest current rates of COVID-19 at some point during the pandemic; epicentres have shifted from Greater London, to Leicester, and the North (Chen, Ni, Xu, & Yang, 2021; Fronterre et al., 2020). However, emerging over a longer period, data have demonstrated that there are also regions which have observed enduring increased rates of SARS-CoV-2 prevalence within England.

In April 2021, SAGE published a report to summarise the best available evidence at the time regarding areas of enduring prevalence (SAGE, 2021). This report set out to look at “risk factors” linked to enduring increased SARS-CoV-2 prevalence in England and considered novel approaches to identify the emergence of new at-risk areas and rates of change in existing areas of enduring prevalence.

Areas of Enduring Prevalence (AEP)

The England map in Figure 1 shows the number of days over a 12 month period since 1st March 2020 that each local authority has spent in the epidemic phase. The epidemic phase is characterised by a greater mean number of daily cases, higher variability, and a stronger correlation between case numbers across consecutive days. A local authority is assumed to be in the epidemic phase if the probability of epidemic exceeds 0.75 (Gov.uk, 2021)

The local authorities selected for this study as areas of enduring prevalence are those with the highest number of days spent in the epidemic phase between 1/3/20 and 28/2/21.

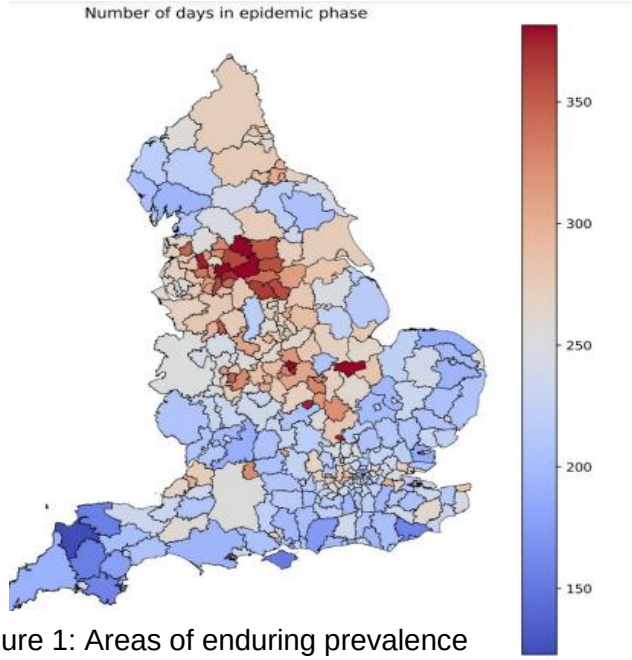

Figure 1: Areas of enduring prevalence
(Gov.uk, 2021; SAGE 2021)

2. Methods

This was a mixed methods study, involving qualitative interviews and collection and analysis of data on various indicators. DsPH in the eleven local authorities identified by SAGE as areas of enduring prevalence (AEP) (Gov.uk, 2021; SAGE, 2021) were invited to take part in the research, and nine of these agreed. A set of comparison areas (CA) were selected using purposive sampling, according to recommendations by Directors of Public Health (DsPH), the Association of Directors of Public Health (ADPH) and Public Health England (PHE). Selection of CA was also based on statistical similarities to the AEP, as shown in Appendix 1, as to areas that were similar to AEP in some respects (including deprivation, age, or ethnic mix) but with lower COVID-19 prevalence. Two of the CA were included as they had been assessed as statistical neighbours to two of the AEP (PHE, 2019) (Appendix 1a). Statistical neighbours are defined as those that are similar in terms of levels of deprivation, whether urban or rural, and on population mix of young, old, and ethnic minorities (PHE, 2019). Locations of the AEP and CA are shown in Figure 2.

Data on a range of indicators were collected on the local authority areas included in the research, to reflect some of the themes that were emerging from the interviews with the DsPH and also from the literature, including the impact of overcrowded households and employment. Indicators were gathered from readily available data sources at the Office for Health Improvement and Disparities (formerly Public Health England fingertips) and NOMIS (Official Labour Market Statistics, ONS). Median values for AEP and comparison areas were calculated and compared using Mann Whitney tests to identify any significant differences.

Semi-structured interviews were carried out with DsPH in 19[1] local authority areas across England, between July and November 2021. Nine interviews were in areas that were identified as AEP and ten were in CA, to gain a better understanding of why certain areas experience sustained prevalence. Local authorities have been anonymised (see Appendix 1b for codes used for the local authorities).

[1] 18 DSPH and one other senior lead. 19 interviews including a pilot interview in one of the comparison areas.

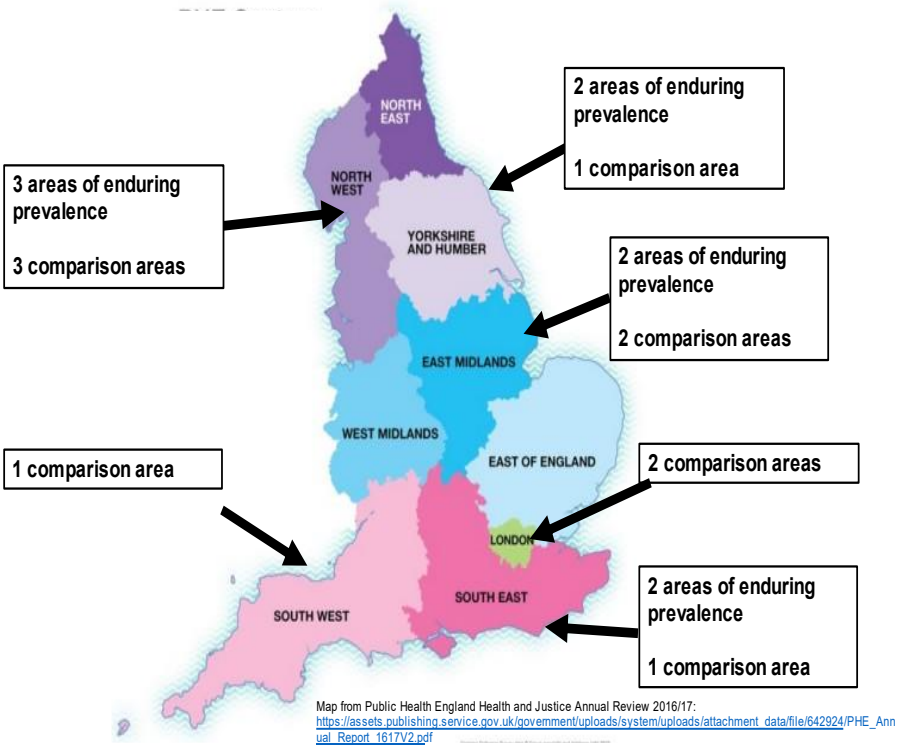

Figure 2. Local authorities included in the research

All interviews were around an hour in length and included 15 questions. The interview schedule (Appendix 2) was devised based on existing literature and in collaboration with the project steering group (details on inside front page), Public Health England (PHE) and the Association of DsPH (ADPH). The interviews were conducted online via Zoom or Teams by two researchers (AH and CL) between June and November 2021.

The interviews were thematically analysed using an iterative coding process (Braun and Clarke, 2006). The interviews were coded by AH and CL using NVivo, and a sample of a third of the coding was reviewed by AH, CL or SJ. The development of the initial coding framework was guided by the research questions and the topics that were raised by the participants during the interviews. The codes were iteratively adapted and restructured throughout the initial coding stage and as a result of discussions between the researchers.

To begin with, all transcripts were coded using the initial coding framework. All DsPH were asked to provide their opinion on what factors may drive enduring prevalence and what local strategies may be effective in reducing COVID-19 rates (local strategies are discussed in more detail in Report 2). Thus, the initial analysis provides a broad picture of the themes that have been discussed across all included local authorities.

Subsequently, the views of DsPH on the key drivers of prevalence in each AEP or CA were analysed separately before comparing between groups. The aim of the within- and between-group comparison was to identify similarities and differences between areas of high prevalence or low prevalence respectively. The comparison was conducted using tabulations and counting of instances discussed by directors of public health with regards to factors contributing to enduring prevalence, effective strategies to locally manage prevalence rates and the main barriers in managing COVID-19 locally.

Finally, 1:1 comparison of AEP and CA which are statistical neighbours was conducted. This analysis provided an opportunity for deeper exploration of reasons for differences in prevalence rates in similar areas.

3. Results

Analysis of indicators associated with enduring prevalence

AEP and CA

The indicators collected are summarised in Table 1 below which gives the median (middle) values for the AEP areas and CAs for each of the indictors considered (also see box plots and chart in Appendix 3). Overall, there were higher levels of deprivation in AEP than in CA. Population density was lower overall in AEP than in comparison areas but was much higher than the national average. The proportion of people aged over 16 from ethnic minority groups was higher, although not significantly higher, in the AEP (21.4%) than in the comparison areas (14.3%) and the national average (13.6%). The proportion of the population from ethnic minority groups was significantly higher in several of the AEP than the national average.

The percentage of people in overcrowded housing tended to be higher in the AEP than in comparison areas, except for the London local authorities. If the London local authorities were excluded from the analysis, the proportion of people in the AEP living in overcrowded housing would be significantly higher.

The AEP tended to have higher proportions of people working in manufacturing, wholesale, retail and education, than the comparison areas; although some of the comparison areas also had rates above the national average. The percentage of people in employment was significantly lower in AEP (69.7%) then in comparison areas (75.4%). The percentage in occupation group 8-9 (process, plant and machine operatives, and elementary occupations) was significantly higher in the AEP (20.7%) than in the comparison areas (15.9%). There was a slightly higher proportion of people on out of work benefits in AEP. The proportion of people travelling to work as a passenger was higher in the AEP than in the CA, whilst the proportion travelling to work on public transport was higher.

The proportion of the population with a second COVID-19 vaccination was generally much lower in AEP(66.3% compared to 74.7% for CA). Data on booster uptake was not available at the time of writing. The proportion meeting 5-a-day guidelines was significantly lower in AEP.

Table 1
Key characteristics of AEP and CA (local authority level)

Indicator	AEP Median (middle) values Red = AEP significantly different to comparison area (p<0.05, Mann-Whitney test)	CA Median (middle) values	England Average (#=Great Britain)
Deprivation Socioeconomic deprivation decile group, from 1 (high) to 10 (low), IMD 2019	3.0	4.5	5.5
Ethnicity % population aged 16+ from ethnic minorities 2016	21.4%	14.3%	13.6%
% Age under 5 2019	6.9%	6.1%	5.9%
% Age 5-15 2019	15.2%	13.9%	13.4%
% Age 16-24 2019	10.9%	9.5%	10.6%
% Age 25-64 2019	51.0%	51.8%	51.8%
% Age 65+ 2019	15.5%	17.0%	18.4%
% In Overcrowded housing 2011	6.0%	3.4%	4.8%
% in Employment 2020/21	69.7%	75.4%	75.1%
% on Main Out-Of-Work Benefits 2016	9.9%	9.1%	8.4%#
Method of travel to work: Public Transport, 2011	7.6%	8.6%	11.3%
Method of travel to work: Passenger in car/van, 2011	4.6%	3.5%	3.3%
Work mainly at or from home, 2011	2.2%	2.6%	3.5%
Employment by occupation, % Group 1-3, 2020/21 Managers, directors, and senior officials. Professional occupations. Associate professional and technical occupations	42.5%	47.5%	50%#
Employment by occupation, % Group 4-5, 2020/21 Administrative and secretarial occupations. Skilled trades	17.9%	19.1%	19.2%#
Employment by occupation, % Group 6-7, 2020/21	18.8%	16.7%	16.1%#

Caring, leisure and other service occupations. Sales and customer service			
Employment by occupation, % Group 8-9, 2020/21 **Process, plant, and machine operatives. Elementary occupations**	20.7%*	15.9%	14.7%#
% Employed in manufacturing 2020	12.3%	7.8%	7.9%
% Employed in construction 2020	4.6%	4.4%	4.8%
% Employed in Wholesale and Retail Trade 2020	18.5%	16.1%	14.9%
% Employed in Education 2020	10.7%	8.9%	9.0%
% Employed in nhs/care/social work 2020	15.3%	15.3%	13.6%
Homelessness **Statutory homelessness, rate per 1,000 households, 2017/18**	2.0	2.2	2.4
Job density jobs in a given area relative to the resident population (1=1 job per person) 2019	0.78	0.75	0.88
Population density **total population per square kilometre (2019)**	1,498	2,022	432
5-a-day **Proportion of the population meeting the recommended '5-a-day' on a 'usual day' (adults) 2019/20**	48.0%	53.1%	55.4%
Clinically vulnerable **% reporting a limiting long-term illness or disability. (2011)**	18.25%	18.40%	17.6%
% vaccinated with 2nd dose (as at 24/11/21)	66.3%	74.7%	80.1%

Sources: PHE and NOMIS

AEP compared to the national average

The AEP areas overall had higher levels of deprivation, people claiming out of work benefits, overcrowded housing, population density, and people classed as clinically vulnerable, compared to the national average. AEP had lower levels of employment, job density, proportions meeting 5-a-day guidelines, people with second COVID-19 vaccinations, and levels of homelessness were slightly lower, based on median values (Table 1). Median population density was more than three times higher in AEP compared to the national average (also see chart in Appendix 3b).

The AEP had higher proportions of people from ethnic minorities compared to the national average. The age profile in AEP was younger, with more people aged 15 and under and fewer aged over 65. There were higher proportions of people in AEP employed in manufacturing, wholesale, and retail, also slightly more in education and care/NHS work. There were higher proportions of people belonging to the less skilled occupational groups. A

smaller proportion of people travelled to work by public transport in AEP compared to the national average and slightly more in AEP travelled as a car/van passenger.

Infection rates

CA were chosen because they were similar to the AEP, and as well as being similar in terms of the indicators (such as deprivation levels) that were discussed in the previous section, infection rates in the CA overall were also similar to those in the AEP. Figure 3 below shows that many of the CA, which are shown in blue, also had infection rates that were higher than the England average at various points during the course of the pandemic.

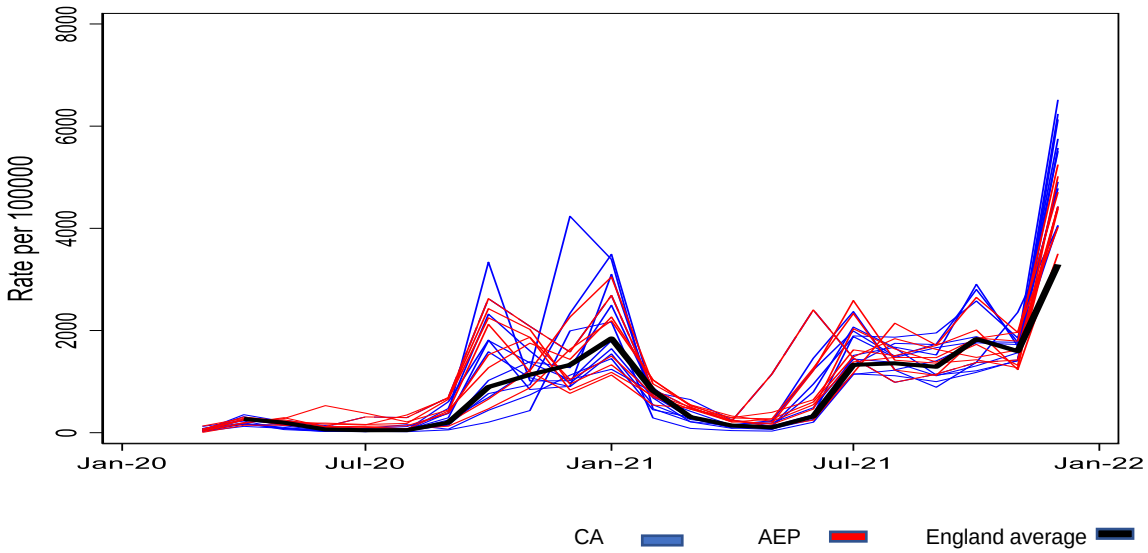

Figure 3: Infection rates in AEP and CA (GOV.UK, 2021; ONS, 2020, 2022).

Interviews with Directors of Public Health (DsPH)

Nineteen interviews were conducted with Directors of Public Health (DsPH) across England, in areas of enduring prevalence and lower prevalence (CA), between July and September 2021. All DsPH were asked what they thought were contributing factors for enduring prevalence. Factors considered to be associated with higher, prolonged prevalence rates included deprivation levels, population density, overcrowded housing, , work-related factors including nature of work and employment conditions, and vaccination uptake. These structural factors also intersected with demographic factors including ethnicity and age. Deprivation and nature of work was often jointly discussed as creating barriers for people to financially afford to self-isolate or to work from home. Overcrowded housing conditions and densely populated areas were mentioned as facilitating rapid transmission within communities. Higher persistent transmission rates were also observed in different ethnic and age groups in different areas, however these often coincided with other factors such as deprivation levels or housing conditions. Participants emphasised that the interaction of various factors could create a “perfect storm” for enduring high transmission rates. There was a strong sense from the interviewees that these factors were often of a structural nature which revealed pre-existing systematic health inequalities in certain areas.

Deprivation

Similarities between AEP and CA

Nearly all participants identified deprivation as one of the most important influences on enduring prevalence, particularly in terms of the proportion of people on low incomes or in low quality or overcrowded housing. Participants in both AEP and CA highlighted that wards, super-output areas or geographical areas within their local authorities were more deprived than others: with some participants saying that they could have predicted where the areas of enduring prevalence were likely to be:

> "I mean, it's classic public health, it's what we're seeing, you know, you can pinpoint the areas where you're going to end up with higher prevalence." (P1, CA)

> "XXX has the second lowest income per household in the country…So that economic impact has affected us dramatically during COVID." (P18, AEP)

Differences between AEP and CA

Levels of deprivation were higher overall in the AEP. Although all participants discussed the impacts of deprivation, participants in the AEP were more likely to refer to deprivation, to describe the local authority as having higher levels of deprivation than the national average, and to discuss the impact of deprivation within their local authority areas, often when combined with other factors such as overcrowded housing or with demographic factors such as ethnicity.

> "I guess we would be considered a deprived community. Many of our wards, or super-output areas would be considered in the lower quintile for deprivation. So, I mean, I would like to describe it as probably an area of general deprivation with pockets of affluence, as opposed to the other way around." (P5, AEP)

> "So, it's quite a heavily deprived population that's got some areas of affluence but in the main it's a more deprived population." (P19, AEP)

Population density

Several participants across areas of varying prevalence also identified population density as a risk factor for community transmission, although no meaningful differences were identified between areas of varying prevalence.

> "So, I think there's multiple factors here, and I think some of it could be in relation to population density, and I think that's what makes XX stand out in comparison to other areas …. But a lot of people live within the inner wards of XX. It is around the occupational risk. So, we know that those people that are in health and social care or manual and routine occupations have that higher risk of COVID-19, and that reflects the types of workers that we have within the town." (P11, CA).

> "In our county, it's the areas of denser population, it's the areas of poorer people, it's the places where you've got churn, where people are having to go out to work. And that absolutely matches definitions of populations impacted by enduring transmission. As I say, that's in very small areas." (P12, CA)

Ethnicity and age

Similarities between AEP and CA

When asked about the risk factors for COVID-19 transmission, most participants mentioned the role of ethnicity, although its role was quite complex. Several participants suggested that when deprivation is accounted for the differences in prevalence by ethnicity are reduced or disappear:

> "There's an ethnic divide, and deprivation gradients, so different ethnicities are more or less likely to take up vaccination and there's a deprivation issue. So, more deprived populations less likely to be vaccinated, but as deprivation decreases, what we're seeing .. is that that ethnicity gap disappears. So, the low uptake in black and black British groups or in Asian groups disappears as deprivation reduces. So, it's a function of deprivation and ethnicity, rather than ethnicity per se." (P1, CA).

Participants also discussed links between housing and ethnicity. Residents from ethnic minority backgrounds were more likely to live in multi-generational households, increasing the risk of young people contracting COVID-19 and passing it on to older family members, and in overcrowded households, which is explored more fully in the 'Housing' section below. Participants also discussed links between ethnicity and vaccination uptake, which again is discussed more fully in the 'Vaccination' section below; vaccination rates were lower amongst residents who described their ethnicity as South Asian, Black African, Black British, Black Caribbean and White Other, amongst others, although again participants said that this was also influenced by deprivation. Several participants argued political motives or mistrust towards government being behind the vaccination hesitancy in certain ethnic groups, and this was also a factor in lower vaccination rates among people in younger age groups.

Several participants discussed the lack of flexibility in the way that the national vaccination programme was rolled out, as people in older age groups received the vaccine first, and local authorities could not start vaccinating people in younger age groups until all the older groups had been offered the vaccine nationally.

Differences between AEP and CA

Participants in the AEP were slightly more likely to refer to the impact of having a younger population on vaccination rates, as discussed above, due to the way that the vaccine rollout was organised:

> "Areas with higher percentages of older people got more vaccination protection, and those of course were areas with the lowest risk, like the south west..,lower historic case rates got higher levels of protection through the vaccination programme, it was a structural inequality." (P18, AEP)

Employment

Similarities between AEP and CA

Nearly all participants identified factors relating to employment as one of the drivers of enduring prevalence. Several participants said that, firstly, people working in occupations including manufacturing, and who were unable to work from home, were at greater risk of transmission. The proportion of people in both these groups was higher in both the AEP and CA overall than the national average.

> "So, there is…there's probably no one individual employer that stands out but, kind of I guess, quite a lot of manufacturing sector. …we've got, sort of, lots of warehouses

> that do packaging and sending things out or receiving things back for mail order and online ordering.“ (P6, AEP).

Participants linked being in a low-income job or one with more precarious employment conditions to increased risk of transmission. This was linked to ability to self-isolate; participants said that people who did not receive sick pay, who were on zero-hours contracts, had precarious employment terms, or were self-employed but did not qualify for support grants, found it more difficult to take time off work in order to self-isolate. They might also be reluctant to take a COVID-19 test, as they would not have been able to afford to then take time off work to isolate:

> “So, I think we had quite a lot of people, where isolation was difficult financially, in terms of zero hours contracts and not getting paid holiday and sick time and all of those issues, which I guess, led to some reticence to get tested, some reticence to use lateral flow testing particularly.” (P3, CA)

> “But they are deprived, it is a deprived area… a really really high proportion of blue-collar workers, many many with, you know, only statutory sick pay or zero-hours contracts. So, from a point of view of being able to take ten days off, or 14 days off as it was to isolate, and everybody within that household who quite often worked in the same locations or certainly in the same type of work….It wasn’t viable.” (P8, AEP)

> “Equally, the challenge then comes on top of that, with the economics that go with it. So, if you’re a taxi driver, sole income, you don’t qualify for support grants because of the nature of what you do, you get a positive COVID test, you’re in a real dilemma as to whether you’re going to comply, or whether you’re not going to comply, because it then becomes, will I have enough money to keep me going? “ (P5, AEP)

Several participants said that employers’ attitudes to sickness absence also influenced employees’ ability to self-isolate when necessary, as some workers, particularly those with more precarious employment conditions, might feel that their jobs were at risk if they took time off work to self-isolate. Several participants also discussed disparities between workplace policy and practice as illustrated by the quote below:

> “But I think the other element of that as well is that, you know, we’ve got more people who are in insecure work or potentially in jobs where, you know, employment practices aren’t gold standard. So, people will feel their jobs are at risk if they can’t go in, which then, obviously, means that there’s pressure for people not to self-isolate or not to test if there’s that risk that they could lose their job, or that they won’t get paid for the period where they need to isolate.“ (P6, AEP)

Participants also linked sustained prevalence to factors related to employment, including living in shared accommodation. Several participants identified car sharing as a factor, especially at the beginning of the pandemic when people were advised to avoid public transport and resorted to car sharing instead. Participants reported that car sharing was more common among workers who were on lower incomes who were trying to reduce transport costs, and who travelled short distances to work, or who worked in factories that were difficult to access via public transport. Although at one point national advice was not to car share, participants said that residents had to do this or they would not be able to go to work. Participants also said that use of public transport increased transmission risk, especially when transport was overcrowded:

> “The other thing significant to mention … was around the role of car sharing in transmission of COVID. I think earlier in the pandemic it was because I don’t think

people understood the risk of being in a very small enclosed space with other people. We also recognised that because of the nature of the town some of the warehouses and factories we engage with tend to be on industrial estates which are very difficult to get to by public transport…if they didn't car share then they wouldn't be able to get to work, so it became a bit of a catch 22." (P11, CA)

Differences between AEP and CA

In the interviews, participants in AEP were slightly more likely to refer to having large workplaces within their local authority area. There were many references to ability to self-isolate in both the AEP and CA. This appeared to be strongly linked with deprivation, and in CA that had significantly higher levels of deprivation than the national average, respondents were also likely to discuss this issue. There were slightly more references to car sharing in the AEP than in the CA, and participants from local authorities that were more deprived than the national average were also more likely to discuss car sharing.

"Work patterns…so it's not people that are travelling huge distances, they travel fairly tight distances, probably shared transport, because they're not affluent enough to have lots of cars that sit around and you can isolate yourself, and then the nature of the work might be in quite confined industries, you know, so if you're working in the snack food industry, which is one of the industries that we have here…And it was a common…. theme of the factors, they often live together, socialise together, and travel to work together. " (P15, AEP)

Housing

Similarities between AEP and CA

Most participants identified issues related to housing, particularly overcrowding, as key drivers of prevalence. Household transmission of COVID-19 was reported to be more likely in larger households, with variation in transmission rates from different variants of COVID-19. Several participants said that the risk of household transmission was increased for people living in houses of multiple occupancy (HMOs), or in three generational households where younger people might contract COVID-19 and it would then spread to older family members. Overcrowding made it more difficult for people to isolate from other members of their household where necessary. Several participants said household transmission rates were higher in certain geographical areas within their local authority than others, or people from certain ethnic groups were affected more:

"I think the other thing that we have certainly seen is that higher household size has meant that we've had higher numbers of cases, you know, because if it spreads through a household, we might have eight people in a household rather than four, for instance." (P6, AEP)

"The other thing to also mention, I think, again when we look at those demographic groups, is how we have a significant number of houses of multiple occupancy within the town, but actually we've got a significant probably unspoken number of houses with multigenerational families, so very large families living within single households. What we have identified with COVID is very much that if COVID gets into the house then you are very likely to pass it throughout your close contacts within that house." (P11, CA).

Differences between AEP and CA

Levels of overcrowding were higher in the AEP overall than in the comparison areas and the national average, and participants in the AEP were slightly more likely to identify overcrowded housing as a risk factor for prevalence. In addition, although national guidance on reducing transmission was often based on the idea of a 'household' being limited to people living in one house, participants said that residents sometimes viewed their 'household' as spanning much further than this in terms of caring responsibilities, including child-care/ provision of food, perhaps spanning down a street or even several streets, increasing the risk of community transmission. Participants said that this was linked to deprivation and happened when people relied more on family and/or other close social contacts than on more formal networks. Participants in AEP were more likely to identify this as a risk factor than those in CA.

> "And when we looked at epidemiological patterns of transmission, not only was there a high prevalence of onward transmission within household, but on the same street you'd have, you know a case, index case, then you'd have the grandmother, then there was the aunts and uncles. So, you know, even within a street you could almost follow the epidemiology of not just communicating it between each other, and this was even when households weren't meant to be mixing, because they see those other households, even though they're at different addresses, as part of their household…. You know, they had… caring responsibilities and it was just the way that they lived, they just happened to have slightly different front doors, but they were all one family or one household as far as they were concerned. So, the definition of a household was completely different in this particular area. As I said, very very close knit…, basically they just want to feed their kids and, you know, be able to live their lives." (P8, AEP)

References to housing in CAs were more likely to relate to initiatives to improve the quality of housing, especially in one local authority where social housing was managed directly by the local authority, and a person-centred approach to housing policy had been adopted. The DsPH felt that this had improved residents' health and helped to explain why the local authority was not an area of enduring prevalence despite it having other potential risk factors such as higher levels of deprivation than the national average:

> "So, I think, you know, the fact we don't have a large percentage of our housing in multiple occupation... And we're the only borough that has taken back inhouse our social housing stock. So, we have no registered social landlords in XX, we do have private rented stock, but not to the same extent. So, that has, you know, enabled us to really focus on healthy housing. So, housing policy is under the director of adult social care and health, so it's a very much public health, person centred approach to housing policy." (P7, CA)

Vaccination rates

Similarities between AEP and CA

Most participants discussed inequalities in vaccine uptake, as discussed below, although participants asserted that these inequalities were alleviated to some extent by the wide range of interventions and initiatives that they implemented, which are described in more detail in Report 2. Participants in both AEP and CA asserted that vaccination uptake was lower in more deprived communities, and among people from certain ethnic minority groups and younger age groups. Several participants also mentioned gender differences in uptake, with one participant saying that rates were particularly low in black males

Many participants said, firstly, that people in more deprived areas within the local authority were less likely to take up the offer of a vaccine, reflecting uptake of vaccines for other illnesses. Several participants said one potential explanation for this was that residents from more deprived populations, particularly, might feel disengaged from the community. Other reasons included difficulties accessing vaccination sites among people from these communities, along with residents not being registered with a GP, and hesitancy to come forward for a vaccine among people from non-registered migrant populations. Several participants said that rates were lower among people from ethnic minority backgrounds, again often linked with levels of deprivation, and among younger people and student populations.

> "…What we know of vaccination more broadly is that coverage is higher in more affluent populations and in white populations. And COVID turned out to be no different. So, you know, from the outset, from every other vaccination programme that we've got, from childhood vaccinations through to flu …. It's difficult to think of what we should be doing that we're not doing …but there's still a gap….There's still a gap between black, Asian and white and a gap between rich and poor, less than it perhaps would have been, but that's been our approach." (P4, AEP).

> I don't think you can get away from the wider determinant picture here. So, thinking about socioeconomic background, thinking about deprivation … You know, very highly educated who will push their way to the front have been able to take advantage of what's been on offer really. Whether it's either testing, understanding about staying at home and social distancing measures that we had, the non-pharmaceutical interventions, or whether it was pushing ahead to get the vaccine done. Being at the front of the queue, basically, when your turn came." (P17, AEP).

Differences between AEP and CA.

As discussed in the section on age above, participants in AEP were slightly more likely to refer to the impact of having a younger population on vaccination rates, due to the impact of the vaccine rollout which targeted areas with older populations first.

Mobility in and out of local authority areas

Similarities between AEP and CA

Most participants discussed the impact of travel in and out of their local authority area on prevalence, including travel by university students and by tourists, as well as by commuters. This affected transmission to a greater extent when neighbouring local authorities had high transmission rates, which was often linked to deprivation in these neighbouring areas. DsPH also discussed transmission linked to tourism, although tourism had varied across different stages of the pandemic and had been impacted by lockdown restrictions. Several participants discussed transmission linked to local lockdowns in other areas. One DPH discussed transmission linked to neighbouring local authorities being under tighter restrictions close to Christmas 2020, so people travelled to the local authority area for Christmas shopping, whilst others reported people travelling into their local authority area to visit hospitality venues such as pubs and restaurants, either due to lockdowns in other areas or because they had family or other connections there:

> "One of the reasons that we tipped from a (tier) two into a four in a matter of two weeks, is because it was coming up to Christmas and nobody could shop in London….so they all just drove into XX 'cause you could go shopping there." (P8, AEP).

> "Whereas you look at somewhere like XX, it was surrounded by areas that really had some difficult challenges. It absolutely is deprivation, types of occupation, some of those cultural things that we talked about, but then there's these really interesting wider drivers that I don't think we'd ever really properly understood before... So that whole local lockdown thing was very complex because our borders are not the way that people live their lives. So really complex about understanding the geography of an area as well as some of the deprivation factors." (P17, AEP)

Differences between AEP and CA

Participants in CA were more likely to identify travel in and out of the local authority area as a risk factor for transmission. One participant in an AEP said that students travelling home for Christmas had not been so much of an issue in the more deprived area in which she was DPH, as students tended not to live away from home. DsPH discussed people in low paid jobs, which were more common in the AEP, being less likely to travel out of the local authority area for work, and to work closer to where they lived:

> "I think we have a less mobile population in terms of people going in and out of the borough. I think there is some data to support that, although probably not particularly robust data. But I think things like the January wave, for instance, XX doesn't have as many young people who are away in higher education and then, sort of, coming back for Christmas holidays and brining Alpha variant with them, for instance, from other parts of the country." (P6, AEP).

The combined impact of factors that lead to enduring prevalence

Similarities between AEP and CA

Most participants said that enduring prevalence was likely to be caused by the interaction between several risk factors, including deprivation, factors related to employment including inability to self-isolate, and factors related to housing including living in overcrowded housing. These factors also intersect with demographic factors such as age gender and ethnicity. Although it might be possible that one factor, such as being in an area of multi-generational households, would not lead to enduring prevalence, it was likely that a combination of these factors would lead to prevalence.

> "I think, one of the things we saw as well, I guess, the other bit to link to the sort of employment and economic sort of side of it, is the…back into the housing and seeing stuff going into households. And then through that household, and then into other workplaces, from that household or other social setting. So it was that multi occupancy housing, close packed housing, close communities, with it just coming in, and not petering out and not being able to fully cut off those chains of transmission." (P3, CA)

> "So, we've done an impact assessment looking at how COVID's impacted across lots of different measures in XX, and you can really see that impact at least earlier in the pandemic it was much clearer in terms of especially the South Asian communities. They're the same communities that are more deprived, they can't self-isolate as well in terms of the housing. Might be housed in multiple occupancy. Have to go out to work, don't have job security so don't end up self-isolating, and doing more frontline professions, so it really feels like a nested set of inequalities there." (P14, CA)

Differences between AEP and CA

Participants in both the AEP and CA described geographical areas within their local authorities (wards or super-output areas) where they felt that the combination of several risk factors had combined to cause enduring prevalence, although participants from AEP, where there were higher proportions of 'at risk' groups (e.g. living in overcrowded housing, in low-income jobs or with precarious employment conditions), made slightly more references to this.

> "So, it's almost as if you could have high levels of variation around ethnicity, and not be an area of enduring transmission. You could be an area of multi-generational households, and not be an area of enduring transmission. You may have housing stock that is not as good as some areas, and still not be an area of enduring transmission, or even income levels could be lower …the issue is, when you start to layer these factors on top of each other. So, enduring transmission comes about by areas where it's almost the straw that breaks the camels' back. So, you might have three and be fine, but you won't have six and be fine, you know?" (P5, AEP)

Overview of the similarities and differences between two sets of statistical neighbours

Indicators

There were two pairs of local authorities that met the PHE definition of statistical neighbours (PHE, 2019),

Comparison of the first set of local authorities showed that although they had been matched by PHE (2019) on deprivation, age and ethnic group, there were double the number of people from ethnic minorities in the AEP than the CA. However proportions were relatively high in both compared to the national average. Deprivation levels and age profiles in the two areas were broadly similar, although the AEP had lower proportions of those aged 16-24 years.

Compared to the CA, the AEP had lower levels of employment and higher levels of overcrowded housing, and population density. Levels of homelessness, people classed as clinically vulnerable, and job density were lower in AEP and there were higher proportions with second COVID-19 vaccinations compared to the CA. There was a higher proportion of people in the AEP employed in manufacturing, education and NHS/care work, and higher proportions of people belonging to the less skilled occupational groups compared to the CA. A larger proportion of people travelled to work by public transport in the AEP and a slightly smaller proportion travelled as car/van passengers.

Comparison of the second set of local authorities showed that although they had been classed as statistical neighbours by PHE (2019), deprivation levels were much higher in the AEP. Although proportions were relatively high in both compared to the national average, there was a lower proportion of people from ethnic minorities in the AEP. The age profiles in the two areas were broadly similar, as would be expected for statistical neighbours.

For the second set of statistical neighbours, the AEP had lower levels of employment, meeting 5-a-day guidelines and second COVID-19 vaccinations compared to the CA. The AEP had higher levels of people claiming out of work benefits. The AEP had higher levels of job density and lower levels of population density and second vaccinations. There was a higher proportion of people in the AEP employed in manufacturing and higher proportions of people belonging to the less skilled occupational groups. A much smaller proportion of

people travelled to work by public transport in the AEP and slightly more travelled as car/van passengers compared to the CA.

Interviews

The differences and similarities within and between the two sets of statistical neighbours were similar to the interview findings overall. The key drivers of prevalence, including deprivation, employment, housing, and low vaccination rates, were similar across areas of varying prevalence. Participants in more deprived areas, including the two AEP and one CA, were more likely to identify structural factors such as deprivation, employment and housing as risk factors for transmission. Participants in the CA were more likely to identify mobility as a risk factor. Participants in all four local authorities again asserted that the combined impact of a range of risk factors was likely to lead to high prevalence rates.

Comparison of the first set of statistical neighbours

There were more similarities than differences between thefirst set of statistical neighbours. Both participants asserted that their local authority areas were more deprived than the national average and identified links between deprivation and high transmission rates. They identified factors related to employment including lack of sick pay, being in insecure employment or on zero hours contracts, or being self-employed but not qualifying for support grants, which had an impact on residents' ability to self-isolate if needed, as risk factors for high transmission rates:

> "If you're a taxi driver, sole income, you don't qualify for support grants because of the nature of what you do, you get a positive COVID test, you're in a real dilemma as to whether you're going to comply, or whether you're not going to comply, because it then becomes, will I have enough money to keep me going? …But it's not wealthy, you don't have those reserves, you don't have those opportunities to work from home, like many other areas in the country." (P5, AEP)

Participants in both local authorities said that the proportion of residents from ethnic minority groups was higher than the national average. They also both felt that residents who lived in larger or multi-generational households had higher transmission risks, and that residents from ethnic minority groups were more likely to live in these households. The AEP participant also emphasised residents' broader definitions of a household as a risk factor for higher transmission rates. As shown in the quote below, residents in more deprived communities or from ethnic minority groups were more likely to rely on informal networks for a range of issues including child-care, and to view people in these networks, who might live in a different house, as part of their household:

> "So, what we have is, one person in the house gets it, and particularly if you've got a multi-generational household, or a wider household, or even informal networks…And clearly, so if one person gets it there, the likelihood is that's going to be transmitted somewhere else." (P5, AEP)

> "If you live in a multigenerational household and you provide the care to other people in your household it's very difficult for you to isolate effectively. Measures we would put in place, such as offering people hotel stays, for example, so that they could go and isolate somewhere else, were not taken up because it didn't match with people's life needs, for example, caring responsibilities, whether it's children or whether it's older relatives." (P10, CA)

In the interviews, participants in the two local authority areas described similar age profiles, apart from a higher proportion of 16–24-year-olds than the national average identified by the DsPH in the CA. The participant identified this high proportion of 16–24-year-olds, along with the impact of a large student population, as risk factors for high transmission rates. Young adults, including students, were more likely to work in public facing jobs, including in hospitality. As well as contributing to higher levels of mobility in and out of the area, students and other young adults, were also more likely to attend social gatherings than older adults, and higher transmission rates were also linked to increases in social gatherings around specific events, such as when exam results were released:

> "They [young adults] were obviously much more likely to, A, be doing the jobs where they'd be at risk, so working as waitresses, waiters, bar staff, et cetera, and also more likely to be engaging in the circulation, the gatherings that were allowed then in the groups of six and going out to some of those hospitality venues. There was a very stark decline when our population reduced, and students went home, but actually that age group remained our highest age group and had a peak again during the summer months. So, our resident young adults are also more likely to engage in gatherings. And of late we've seen our post A level results, our 17- and 18-year-olds became our highest rates, again just entirely linked to the hospitality settings, so gathering. I think there's a really strong connection between people engaging in those social activities where they're more likely to get close to another, less likely to be wearing face coverings, more likely to be in an enclosed indoor space that seems to be contributing to that." (P10, CA)

Participants in both areas identified lower vaccination rates than the national average as a risk factor for high transmission rates. Participants identified a range of reasons for lower vaccination rates, which were similar across the areas, including competing priorities such as work commitments or caring responsibilities, difficulties accessing vaccination sites, difficulties accessing the vaccine due to not being registered with a GP, hesitancy due to cultural or faith beliefs.

> "And I think there's this understanding, that, what I've seen very clearly, is people want to do the right thing. They genuinely do, but it is not always as easy for people to do the right thing in my city, as it might be in some other areas of the country." (P5, AEP)

The DsPH of the CA identified some additional reasons for low uptake, including the impact of the anti-vaccination movement, and also suggested that recorded vaccination rates might not include all vaccinated students, as DsPH could only access vaccination data for students who were vaccinated in England.

> "What I found in XX is that that group that are really unlikely to ever come forward and have the vaccine is actually a much larger percentage. We've got quite a strong anti-vaccine movement in XX, and the willingness and availability of misinformation is very strong, and very difficult to overcome." (P10, CA)

Comparison of the second set of statistical neighbours

The participant in the AEP asserted that their local authority area was more deprived than the national average and identified links between deprivation and high transmission rates. The CA participant described a more affluent area, with lower deprivation rates than the national average, but identified certain more deprived wards or geographical areas within the local authority with higher transmission rates. The AEP participant also emphasised factors

related to employment to a far greater extent than the CA participant, including lack of sick pay and being in insecure employment or on zero hours contracts, which had an impact on residents' ability to self-isolate if needed.

> " [We've got] the affluent on one side and the most deprived in the south of the borough. And we don't really have any manufacturing, there aren't big…any offices or anything like that, it's a very diverse borough." (P9, CA)

> "We had a population who was really trying their very hardest to do everything we were asking them to do. But if you have a zero hours contract and you're being asked not to go to work, and if you don't go to work, you don't bring any money in, you can't feed your family, that's incredibly hard for people." (P17, AEP)

Participants in both local authorities said that the proportion of residents from ethnic minority groups was higher than the national average. Both discussed having diverse populations including members of traveller communities. They also both felt that residents who lived in larger or multi-generational households had higher transmission risks, and that residents from ethnic minority groups were more likely to live in these households.

> "I think in our borough mainly we have got very multigenerational households. So, they're large houses where generation of families live and when we looked at the data most of the transmission was happening within households or within neighbourhoods. So, it's not…we didn't find a lot in workplace or outside, it was mainly in families I think that was the biggest challenge for us…I don't think people really thought seriously about isolating when they had a positive in their own homes." (P9, CA)

Participants in both local authority areas described similar age profiles in the interviews. They both identified lower vaccination rates than the national average as a risk factor for high transmission rates, identifying a range of reasons for this, which were similar across both areas and included competing priorities such as work commitments or caring responsibilities, difficulties accessing vaccination sites, difficulties accessing the vaccine due to not being registered with a GP and hesitancy due to cultural or faith beliefs. DsPH discussed a range of mitigation strategies to address these issues, which are discussed in Report 2.

In common with other CAs, the participant identified mobility in and out of the local authority area as a risk factor for transmission:

> "I think for us the challenge was because XX traditionally has got really good schools, high achieving schools. So we do tend to get people coming from elsewhere across XX to our schools." (P9, CA)

Participants from both areas asserted that the combined impact of a range of risk factors was likely to lead to high prevalence rates:

> "In XX it was particularly people from Eastern Europe or people most likely to be doing the frontline work which put them at greater risk. Taxi drivers, bus drivers, healthcare workers, social care workers, and they came from our more deprived communities where they were living in environments where they were least able to follow some of the other things that we were asking them to do." (P17, AEP)

4. Discussion

The interviews suggest that differences in levels of deprivation, particularly, led to enduring prevalence of community COVID-19 transmission rates. In the AEP, participants were slightly more likely to identify structural factors such as deprivation, overcrowded housing and low paid or precarious employment as contributing factors to enduring prevalence. These findings align with previous research that suggest that large household size and living in a deprived neighbourhood were associated with increased prevalence at times during the pandemic (Riley et al., 2021). Because the CA were chosen to match the AEP, many of the factors identified by DsPH as drivers of prevalence, such as factors linked to deprivation, employment, and housing, were also similar across local authorities included in the research. Infection rates in the CA overall were also similar to those in the AEP overall, and many of the CA also had infection rates that were higher than the national average at various points during the course of the pandemic.

Participants also discussed the impact of the intersection of demographic factors including ethnicity with other factors, which supports previous research that suggests that there are links between ethnicity and transmission rates. In an exploration of exposure to COVID-19 infected residential neighbourhoods by ethnicity, Harris and Brunsdon (2021) found that Black residents were found to be disproportionately exposed to COVID-19 in the first wave, which was partly related to the fact that there were disproportionately more cases found in London at the beginning of the pandemic. Subsequently, the Pakistani, Bangladeshi and Indian groups have had the highest levels of exposure to cases. Higher exposure in the Pakistani group was linked to occupational and environmental exposure such as residential density. The links between deprivation, ethnicity and COVID-19 transmission are complex, and the literature suggests that more research is needed in this area. For example, a review by Armitage et al (2021) suggested that some groups, such as people from ethnic minority backgrounds, men and younger people may need additional support to adhere to Covid guidelines. This is due to differences in capabilities, opportunities, motivations and behaviours, for example they may not have the information required, or the means to adhere to the guidelines, due to financial and other barriers (Michie et al, 2011).

In both AEP and comparison areas, participants described the impact of low vaccination rates leading to higher prevalence of COVID-19. Vaccination rates were lower in the AEP compared to CA and national levels. Participants reported that vaccination hesitancy was of greater concern in deprived areas and in communities that showed more mistrust in government, aligning with the findings of previous research demonstrating unequal effects of infection and mortality in more disadvantaged communities. Previous research (e.g. (Nafilyan et al., 2021) also demonstrates that occupation is linked to vaccination rates as studies show that rates are high in certain occupations (administrative and secretarial, professional and managers, directors and senior officials) and low in others, such as people working in elementary occupations. A significantly higher proportion of residents in the AEP work in elementary occupations, compared to CA. Vaccination status has been shown to effect household transmission (Singanayagam et al 2021). The OpenSAFELY project (The OpenSAFELY Collaborative et al., 2021), which aimed to describe trends and variation in coverage by geographic area and between key groups, showed substantial divergence in vaccination by a number of factors including ethnicity and across rankings of deprivation.

Bambara et al. (2020) describe COVID-19 as a ‘syndemic’: a synergistic pandemic that interacts with and exacerbates a person’s existing non-communicable diseases and social conditions. They suggest that historically, pandemics have been experienced unequally with higher rates of infection and mortality among the most disadvantaged communities and

argue that COVID-19 interacts with and exacerbates existing inequalities in determinants of health, which according to Taylor-Robinson (2019) et al had already begun to rise prior to the pandemic. Many participants said that having several 'risk' factors, e.g., living in a deprived area, in overcrowded housing, with a low paid job and/or precarious employment conditions, and being a member of an ethnic minority group had an impact on enduring prevalence. They emphasised that the interaction of various factors (multi-factorial) rather than one single factor contributed to enduring prevalence which could create a "perfect storm" for enduring high transmission rates. None of the DsPH were confident based on available data how exactly contributing factors interacted and advised that more research is needed to predict enduring prevalence patterns in different areas. The design and nature of this study does not permit further unravelling of the various factors here. In addition, while care has been taken to look at objective comparative data between areas, not all factors discussed by DsPH could be corroborated with data. Therefore, these factors should be understood to be the perceptions of the DsPH and not evidenced claims.

The variation in factors such as deprivation, employment, and housing across the local authority areas, with DsPH often describing 'pockets' of deprivation where a number of risk factors combined, aligns with Daras et al's (2021) research on COVID-19 mortality, which examined the factors that influence prevalence by ward or super-output area. The vulnerability index examined the impact of factors including ethnicity and overcrowded housing on COVID-19 mortality and found high levels of vulnerability clustered within communities.

However, enduring prevalence is a pattern not a singular outcome. It is likely a convergence of viral transmission features that produce this pattern including high risk of exposure, high disease burden, and high risk of onwards transmission (Cevik & Baral, 2021). Furthermore, the factors related to transmission rates are not independent of one another, and this makes it difficult as well as unrealistic to determine how much variability in risk of exposure, disease burden or risk of onwards transmission is attributable to individuals.

The data collected on AEPs showed significantly lower employment levels, a significantly lower skilled workforce and higher deprivation levels than the CA. DsPH know that these are largely areas with challenging socio-economic circumstances, and which already experience poorer population health outcomes. As part of this research, indicators were collected at a local authority level, but in future, analysis of the indicators at a ward/super-output area level for local authorities included in the research would help to increase our understanding of the way that risk factors combine to predict enduring transmission.

While there is a lack of studies that focus directly on enduring prevalence, research in the UK suggests that higher rates of infection are aligned with existing social inequalities. The REACT project reported that large household size, living in a deprived neighbourhood, and Black and Asian ethnicity were associated with increased prevalence at times during the pandemic (Riley et al., 2021). Diet quality has also been shown to affect individual risk, where individuals with the lowest diet scores have approximately 10% greater risk of contracting COVID-19 than those with the highest diet scores (Merino et al., 2021). Although diet was not mentioned by participants in this study, an analysis of the data showed that those in AEP were significantly less likely to have a healthy diet (5-a-day) than CA. National and local government bodies have also recognised these factors relating to individual risk, and suggested that structural issues linked to age, gender, ethnicity, occupation and geography have exacerbated impacts of COVID-19 on certain communities (Local Government Association, 2021; Public Health England, 2020).

Using mortality rates to estimate cumulative infection rates by local authority districts and council areas, Kulu & Dorey (2021) reported that, as of June/July 2020, infection rates were positively related to population density of the area and the level of deprivation. Population

size was also reported to be related to infection rates, in a model of local transmission dynamics in nine broad regions of England in the early stages of the pandemic (Liu et al., 2021). Daras et al's (2021) research also examined the factors that influence prevalence by ward or super-output area; the vulnerability index looks at the impact of measures including ethnicity and overcrowded housing on COVID-19 mortality. Vulnerability was higher in the North West, West Midlands, and North East, with high levels of vulnerability clustered in some communities.

Limitations of the research

The inclusion of two London boroughs in the comparison group tends to skew the results for some of the indicators, especially for proportions of ethnic minorities, overcrowded households, homelessness, job, and population density, where levels are much higher than the national average. For each of the nine AEP, a CA was selected using purposive sampling. CAs were to be similar to AEP in some respects (including deprivation, housing and ethnic mix) but with lower COVID-19 prevalence. The matching CAs were chosen based on suggestions from DsPH, ADPH and PHE. Only two pairs were actually statistical neighbours, as defined by PHE (PHE, 2019). Ideally all the CAs would have been statistical neighbours of the AEP. In addition, AEP were identified by SAGE based on infection rates in from 1st March 2020-28th Feb 2021. It is possible that different AEP would have been identified if infection rates for a different time period had been considered. Finally, the research is based on only DsPH perspectives – future research a wider range of stakeholders that would provide a broader insight into the impact of, and interactions between, different factors.

5. Conclusion

The research suggests that health inequalities influence the wider picture of prevalence rates of COVID-19. Structural factors including deprivation, employment, and housing, converging with demographic factors including ethnicity and age, and vaccination rates, are key drivers of prevalence, and there are key differences in these drivers both within local authorities, and to a lesser extent, between AEP and CA. Further research is needed, ideally at ward/SOA level, on how these factors combine to predict transmission and how this varies between different areas, and on the relative importance of each of these factors.

6. Recommendations

- Conduct further research on how multiple factors interact in predicting enduring prevalence and which are the most important factors. This might include research on the views and experiences of:
  - Employers and employees, and other members of the local partnerships required to work together to respond to workplace outbreaks of COVID-19
  - Key health and social care actors, including Directors of Adult Social Care
  - Community and voluntary organisations, and other 'seldom heard' groups
- Conduct analysis of the indicators included in the report at ward/super-output area (SOA) level for AEP and CA, to allow more detailed comparisons between areas of varying prevalence
- Assess the role of mass movements of individuals into and out of areas of high prevalence.
- Consider actions that can be taken to tackle modifiable risk factors for the enduring prevalence of COVID-19, such as addressing differences in people's capabilities, opportunities, motivations and behaviours in response to vaccination and government guideline engagement in the short term. In the longer term, action to address structural inequalities that disproportionately impact certain groups. Issues to address include house occupancy, nature of work and housing standards.

Summary of Reports 1 and 2

Introduction

UK local authorities that experience sustained high levels of COVID-19 infection are termed areas of enduring prevalence (AEP) according to UK Scientific Advisory Group for Emergencies (SAGE) in 2021. AEP are those with the highest number of days spent in the epidemic phase between 1/3/20 and 28/2/21. The epidemic phase is characterised by a greater mean number of daily cases, higher variability, and a stronger correlation between case numbers across consecutive days. A local authority is assumed to be in the epidemic phase if the probability of epidemic exceeds 0.75 (Gov.uk, 2021). This research aimed to gain expert views and insight into the factors that contributed to enduring prevalence of COVID-19 infections and what local level strategies were implemented and perceived as effective in preventing or reducing transmission rates in areas that saw consistently high prevalence of COVID-19 infections across local authorities in England. The research explored how the local response was facilitated or hindered by local level factors as well as national strategies or guidance.

This Report (1) described the key differences between the AEP and comparison area (CA) local authorities in terms of indicators including deprivation levels, housing and employment. Report 2 (Hartwig et al) explored which potential national and local level barriers could be responsible for the enduring prevalence of COVID-19 infection in certain geographic areas, and which local and national level strategies, policies and guidance have been effective in helping reducing transmission. Both reports identified future research priorities that support continual improvement in local practice and decision-making relating to COVID-19.

Methods

This was a mixed methods study, involving qualitative interviews and the collection and analysis of data on a range of indicators. DsPH in the eleven local authorities identified by SAGE as areas of enduring prevalence (AEP) (Gov.uk, 2021; SAGE, 2021) were invited to take part in the research, and nine of these agreed. A set of comparison areas (CA) were selected, according to recommendations by Directors of Public Health (DsPH), the Association of Directors of Public Health (ADPH) and Public Health England (PHE). For two AEP, statistical neighbours with low prevalence were identified and these were also included as CAs. Statistical neighbours are defined as those that are similar in terms of levels of deprivation, whether urban or rural, and on populations of young, old, and ethnic minorities (PHE, 2019). DsPH in ten CA agreed to take part in the research. Local authorities were anonymised for the purpose of this report.

Indicators were collected for all participating local authority areas, to allow further investigation of some of the themes that emerged from the DsPH interviews, and from the literature review. Indicator data included overcrowding, occupation and employment status. Indicators were gathered from readily available data sources at the Office for Health Improvement and Disparities (formerly Public Health England fingertips) and NOMIS (Official Labour Market Statistics, ONS).

Semi-structured interviews were conducted with 19 DsPH across England in areas of enduring prevalence and areas with lower prevalence. All interviews were around an hour in length and covered 15 questions, including local mitigation measures and barriers to reducing prevalence rates locally. The interview schedule was devised based on existing literature and in collaboration with the project steering group (details on inside front page), Public Health England (PHE) and the Association of DsPH (ADPH). Interviews were conducted online via Zoom or TEAMS between June and November 2021 by two researchers experienced in qualitative research methods. Interviews were professionally transcribed and thematically analysed using an iterative coding process (Braun and Clarke, 2006). The interviews were coded using NVivo and a coding framework guided by the

research questions and the topics raised by the participants during the interviews. Codes were iteratively adapted and restructured throughout the initial coding stage and as a result of discussions between the researchers throughout the coding process.

All transcripts were coded using the developed coding framework. The initial analysis provided a broad picture of the themes that were discussed by the DsPHs. Using these codes as a framework, a comparison of similarities and differences between and within AEP and CA was then conducted, followed by a 1:1 comparison of AEP and CA which are statistical neighbours.

Results

The indicators collected showed that there were higher levels of deprivation in AEP than CA. The proportion of people aged over 16 from ethnic minority groups is higher, although not significantly higher, in the AEP than in CA and the national average. The percentage of people in overcrowded housing tends to be higher in the AEP than in CA, except for the London local authorities.

The AEP tend to have higher proportions of people working in manufacturing, wholesale and retail and in education, than the CA. The percentage of people in employment is significantly lower in AEP than in CA, and the proportion working in lower skilled occupation groups is significantly higher in the AEP than the CA. The proportion of the population with a second covid vaccination is generally much lower in AEP. Data on booster uptake was not available at the time of writing.

In the interviews, participants identified various factors associated with enduring prevalence, including high deprivation levels, overcrowded housing, and low vaccination rates. Deprivation and employment were often jointly discussed as creating major barriers for people to financially afford to self-isolate or to work remotely. Not receiving sick pay, working on zero hours contracts or in insecure employment were thought to be associated with inability to self-isolate. There were strong similarities in the drivers of enduring prevalence described by the DsPH in AEP and CA. All participants asserted that there were differences in these factors between different wards or geographical areas within their local authority, and between different groups, including people from different age groups and ethnic backgrounds. Participants in the AEP were however more likely to discuss the impact of structural factors such as the impact of lack of sick pay or work insecurity, and of overcrowded housing.

Other than the structural differences between local authorities discussed above, such as levels of deprivation, there were no major differences identified between AEP and CA in barriers and facilitators of COVID-19 control. Therefore, in Report 2 (Hartwig et al, 2022), these findings were presented for local authorities overall across varying levels of prevalence.

Participants discussed local level barriers to reducing transmission including residents' hesitancy to get tested, vaccinated or to self-isolate. Participants identified a number of reasons for this, including competing priorities such as financial barriers or conflict with other responsibilities. Other barriers to reducing transmission that were identified by DsPHs at the point of data collection included restrictions around data sharing and delays in accessing data, as well as changes and inconsistencies in national messaging. Participants implemented a variety of mitigation strategies over the course of the pandemic including local contact tracing, testing and vaccination efforts, isolation support, communication campaigns, engagement with business and education, and community engagement. They discussed working closely with local partners including clinical commissioning groups and primary care networks, and with regional networks including PHE, to facilitate a system wide approach to transmission control. Participants also discussed the impact of national strategies including

local and national lockdowns and the vaccination programme. However, as interventions were implemented at pace, evaluation of strategies was sometimes limited.

Recommendations

A number of recommendations were made, based on the interviews and discussions with the steering group. This report recommended that further research was needed on how multiple factors interact in predicting enduring prevalence and which are the most important factors. This might include research on the views and experiences of employers and key health and social care actors, including Directors of Adult Social Care, community and voluntary organisations, along with other 'seldom heard' groups. Analysis of the indicators should be conducted at a ward/super-output area (SOA) level for AEP and CA, to allow more detailed comparisons between areas of varying prevalence. Further assessment of the role of mass movements of individuals into and out of areas of high prevalence should be conducted.

As part of the interviews, the DsPH were asked what research would be of benefit for them to facilitate an effective local response in the future. Many of them wished to see a better evidence base for local interventions and associated messaging which could be used to shape future interventions. Also, there was consensus that more research was needed to understand more deeply community needs, attitudes, and beliefs with regards to COVID-19 to tailor future messaging and mitigation efforts. Finally, the long-term impact of the pandemic was of interest to the respondents, including effects on individual health, visibility of enduring health inequalities, and the wider system for recovery.

Based on feedback from respondents and the analysis of data, a number of recommendations were developed, to build long-term resources to prevent / combat future pandemics or health crises. DsPH experiences of the pandemic provide an important opportunity to reflect on effective strategies for a local response. Better alignment of national and local responses may be needed to create consistency and build a system wide approach to reducing transmission. Improving the partnerships between national and local leaders may help in ensuring that strategies are effective, tailored to local demands and more trusted by the public.

In the shorter term, actions should be taken to tackle modifiable risk factors for the enduring prevalence of COVID-19, such as addressing differences in people's capabilities, opportunities, motivations and behaviours in response to vaccination and engagement with government guidelines (Michie et al, 2011). In the longer term, issues to address include house occupancy, housing standards, nature of work, and tackling structural inequalities

Conclusion

The research suggests that existing health inequalities influence the wider picture of prevalence rates of COVID-19. Structural factors including deprivation, employment, and housing, converging with demographic factors including ethnicity and age, and vaccination rates, are key drivers of prevalence, and there are key differences in these drivers both within local authorities, and to a lesser extent, between AEP and CA. Further research is needed, ideally at ward/SOA level, on how these factors combine to predict transmission and how this varies between different areas, and on the relative importance of each of these factors.

A number of barriers to reducing COVID-19 transmission were identified, including people's hesitancy to get tested, or to self-isolate often related to financial circumstances, to get vaccinated, delays in access to data, as well as structural barriers including the impacts of deprivation. Apart from differences in structural barriers, no major differences in barriers were identified between the AEP and CA. Differences in implemented mitigation strategies do not

appear to explain the differences in prevalence between areas. Participants asserted that more research is needed to understand the effectiveness of mitigation strategies.

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Appendix 1: - List of CA and rationale for their selection

Table 1. List of CA and rationale for their selection	
Region of CA	**Rationale for selection**
Greater London	Statistical neighbour of AEP
Greater London	Statistical neighbour of AEP
Midlands	Comparison area to AEP (suggested by ADPH)
Midlands	Comparison area to AEP (DPH) statistical neighbour of AEP
South East	Deprived areas but less explosive rises than other areas in England (PHE)
Yorkshire/Humber	How does Y&H compare to other areas in England (PHE)
North West	Comparison area to CA (ADPH)
South West	Comparison area to AEP (DPH)
North West	Pilot area
North West	Area with increases, but less explosive than others in NW (PHE)

Appendix 2: Interview schedule

Enduring Prevalence Research

Semi-structured interview schedule

The aim of this interview is to help us gain an understanding of why certain places appear to have higher prevalence of COVID-19 infections than others. We would like to gain views from Directors of Public Health and other local stakeholders who can share their knowledge and experience at the local authority level to discuss potential reasons for enduring COVID-19 prevalence in some regions. We would like to hear your general thoughts on the current situation, what happened in terms of mitigation measures in past waves of the pandemic and what approaches may be taken locally/ regionally to anticipate and reduce areas of enduring prevalence.

Background

Can you please tell me a little about your current role and the local authority in which you work?

Prompts:

- How would you describe your local authority in terms of its population/level of deprivation/manufacturing base etc.?
- How would you describe the region which your local authority is located in?

How would you describe the changes in COVID-19 prevalence in your LA over the course of the pandemic?

Prompts:

- Rates during the different waves
- How does this compare to neighbouring LAs and LAs with similar characteristics?

We would now like to hear your broad views on potential risk factors for regional enduring prevalence of COVID-19.

1. **In your opinion, what are the main factors that contribute to differences in the prevalence of COVID between locations/places?**
   Prompts:
   - What about e.g., population factors, deprivation, nature of work, effectiveness of contact tracing, regional commutes between LAs?
   - What is the interplay between the different factors?

2. **Why do you think certain areas have <u>sustained</u> high levels of prevalence?**
   Prompts:
   - What and how are these factors driving enduring prevalence?

3. **Has the importance/role of these factors changed throughout the timeline of the pandemic? If so, how?**

We would now like to hear your broad views on strategies and factors that have been effective in preventing or reducing regional prevalence of COVID-19.

4. **How effective do you think national level strategies, policies and guidance are in reducing transmission?**
   Prompts:
   - What are most effective strategies/policies at the national level?
   - Has the effectiveness of strategies changed throughout the timeline of the pandemic?

5. **Can you tell us about local/regional strategies that have been effective in helping reduce COVID-19 infection rates?**
   Prompts:
   - Examples of strategies/ policies: regulation, guidelines, fiscal measures, environmental/social planning, service provision, legislation, and communication/marketing?
   - What have been the most effective prevention strategies for your area/ community?
   - Why have interventions been effective/failed? (e.g., different organising of test & trace system)
   - What has helped/hindered the introduction of these strategies?
   - How effective have these strategies been at different times during the pandemic?
   - How is the effectiveness of strategies affected by specific characteristics of localities, places, population, economies?
   - What could be done to intervene earlier and curtail prevalence in regions?

6. **How have you identified any particular population groups for tailored interventions?**

   Prompts:
   - Is this based on previous data about inequalities or new covid-related data?
   - How have you dealt with challenges associated with reaching certain population groups in your interventions?

7. **How has the response to COVID-19 been organised locally?**
   Prompts
   - Which organisations have taken a lead? How have local organisations been working together? E.g., joint forums, with LAs / CCGs / ICSs, resilience hubs?
   - Has there been any misalignment/conflict between local, regional, and national strategies/policies/guidance and how have you managed this in your LA?

8. **How have LAs been sharing information and learning?**
   - Have there been opportunities for you to learn from other DsPHs? Are there forums you find useful in exchanging experiences and knowledge?
   - What do you do differently to other LAs? Why?

We are now interested in the data available and its use in decision making and what future research priorities might be.

9. **What data, evidence and knowledge is used to inform local decision making?**
   Prompts:
   - What sources of data/information do you find useful?
   - How is existing knowledge / data used to inform guidance?
   - What are key data or knowledge gaps that need to be addressed?
   - How could data be used to anticipate places of enduring prevalence in the future?
   - Have there been any issues around data sharing (e.g., between local/regional/national teams)?
   - Has behavioural science informed your approach to encouraging hand hygiene, physical distancing, wearing of face coverings, self-isolation, etc? If so, how?

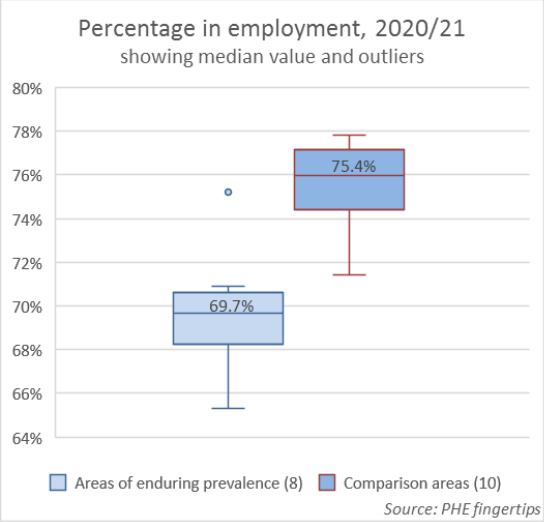
10. **What future research do you think would be most useful to provide insights that can support LA practice and decision making?**
    Prompts:
    - Is there anything that would need more research (e.g. patterns/correlations that cannot be explained)?
    - What are the key questions for research relating to enduring prevalence and future planning?

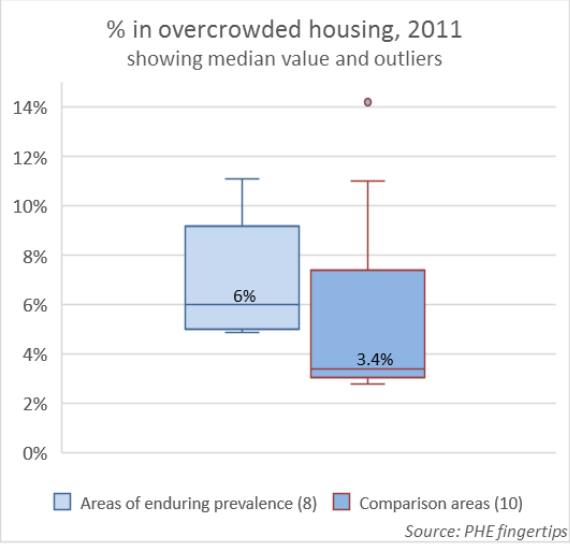
11. **In your opinion, what are the future challenges for preventing or reducing local / regional enduring COVID-19 prevalence?**
    Prompts:
    - Emergence of new variants of COVID-19
    - Support for people to self-isolate (e.g., financial support)
    - Impact of vaccination programme
    - National strategy for COVID19 transmission management
    - Support for places of enduring prevalence in the COVID-19 recovery

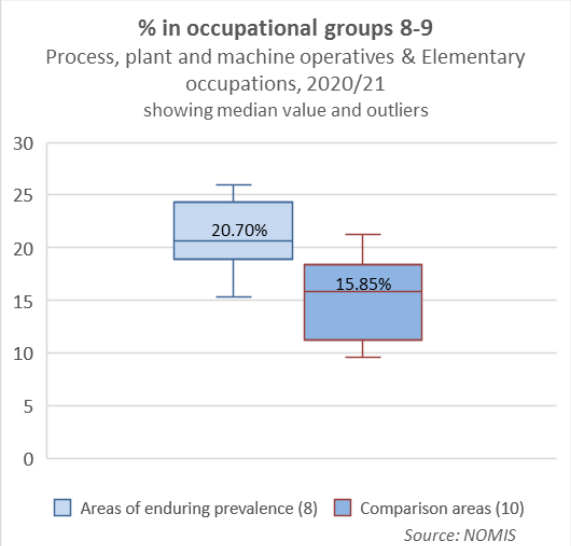
12. **Are there any other stakeholders you would recommend us contacting to gain a better understanding of disparities in prevalence of covid-19 infection? (names / locations / roles)**

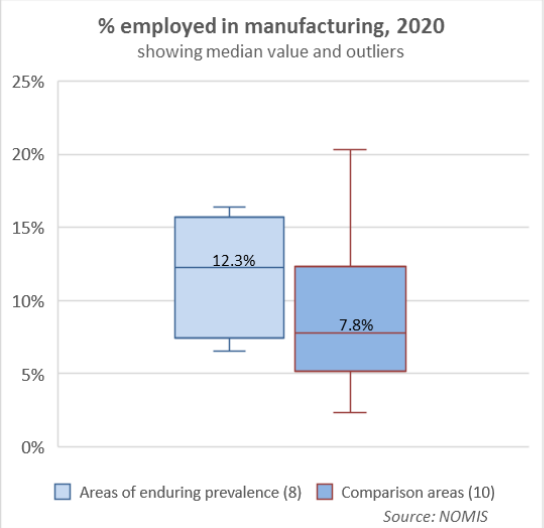
Finally, is there anything you thought we might discuss, that we have not covered?

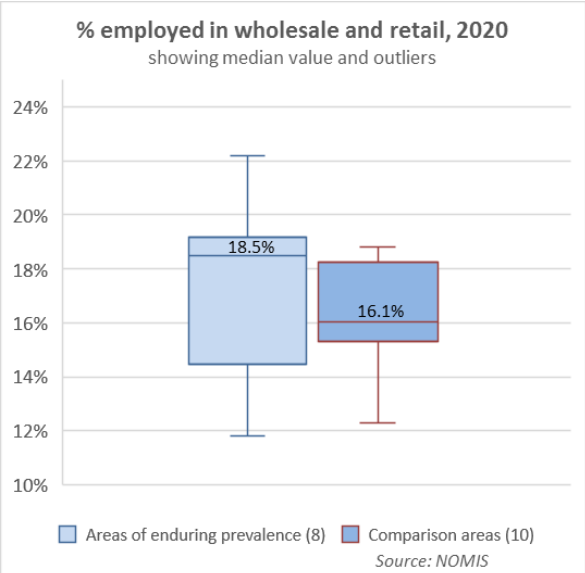
Appendix 3a: Boxplots showing differences between areas of enduring prevalence and comparison areas for selected indicators

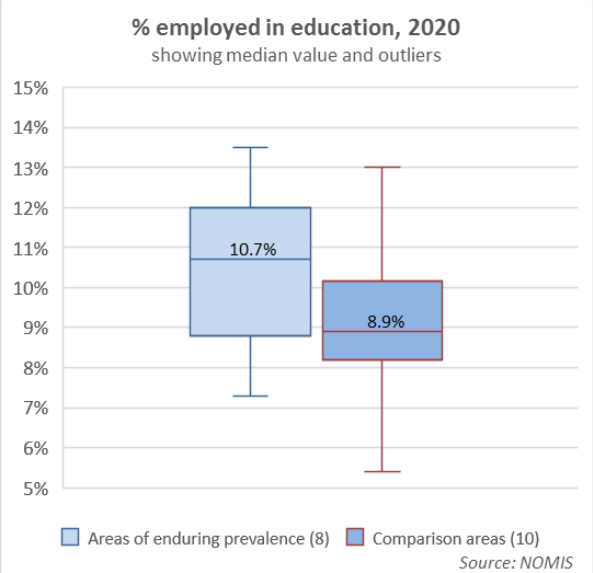


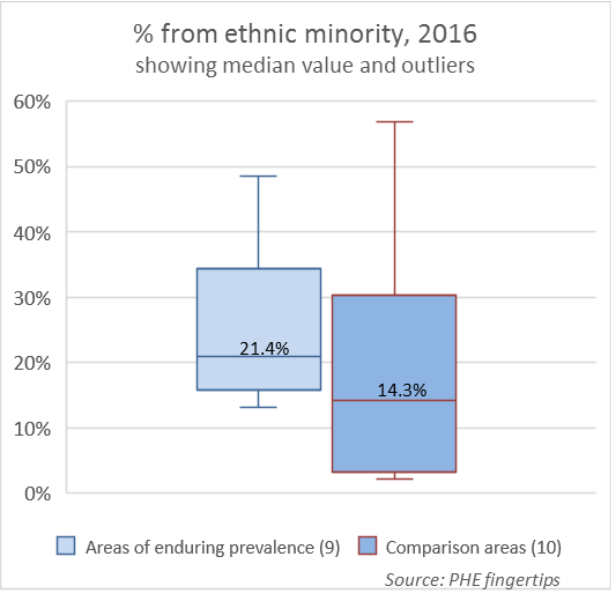


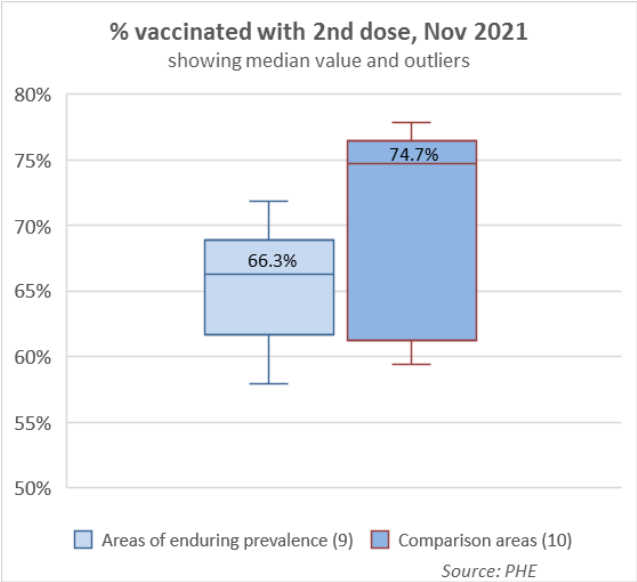


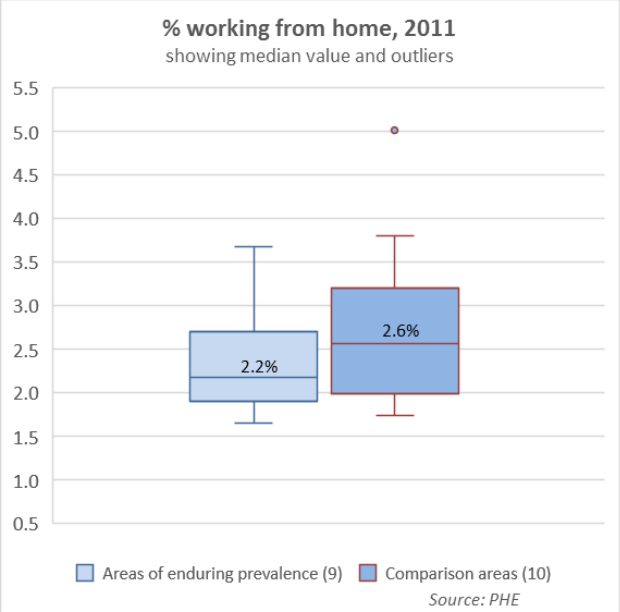


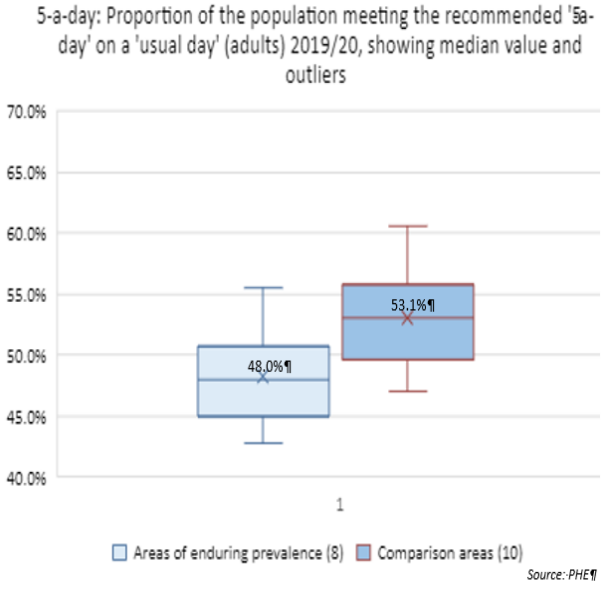






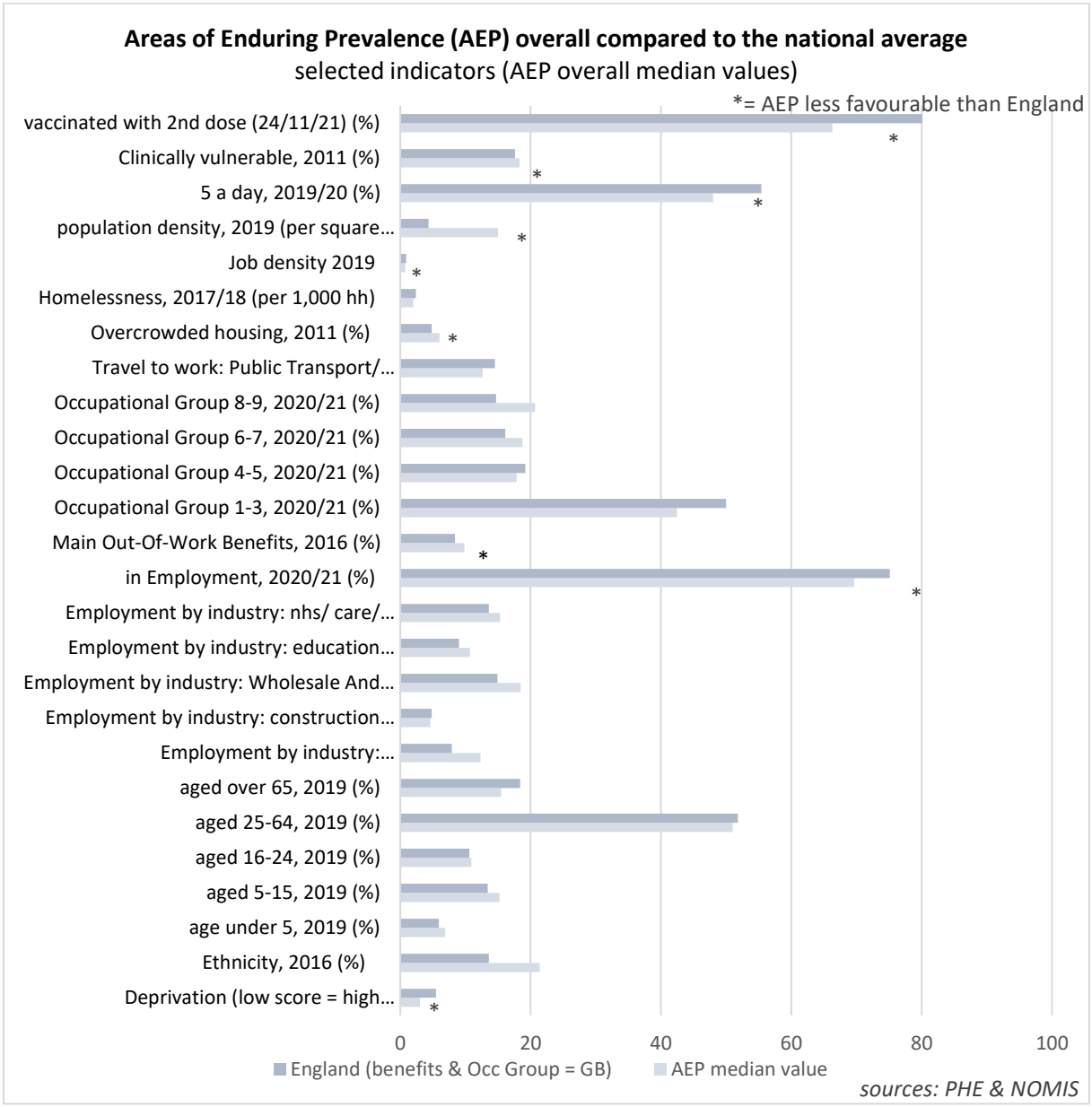






Footnote: The area inside the boxes represents the middle 2 quartiles (50%), with the middle line being the median value. Whiskers generally extend to the maximum and minimum values, with external values more than 1.5 box lengths from the 25th or 75th percentile marked as outliers.

Appendix 3b: AEP compared to national average



The PROTECT COVID-19 National Core Study on transmission and environment is a UK-wide research programme improving our understanding of how SARS-CoV-2 (the virus that causes COVID-19) is transmitted from person to person, and how this varies in different settings and environments. This improved understanding is enabling more effective measures to reduce transmission – saving lives and getting society back towards 'normal'.

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