

Risk factors Associated with Places of Enduring Prevalence and potential approaches to monitor changes in this local prevalence.

Purpose of the paper

This paper is a summary of the best available evidence at the time of writing with respect to two issues:

- The risk factors linked to enduring increased SARS-CoV-2 prevalence observed in some areas of England.
- The consideration of novel approaches which might be used to:
 - identify the emergence of new areas at risk of enduring prevalence;
 - identify the rate of changes in prevalence (positive or negative) in existing areas of enduring prevalence for both existing and new variants of the virus;
 - assess how effective interventions may be developed.

Executive summary

- The particular mix of risk factors in areas of enduring prevalence is complex, inconsistent across geographical areas and are difficult to disentangle. However, they are generally areas with higher deprivation than the England average (high confidence)
- Some settings (e.g. the workplace) may serve to coalesce risk factors which can extend transmission networks to additional settings or communities (medium confidence).
- Modelling approaches, statistical analysis and qualitative research at a more granular level may help to provide insights that identify emerging changes in prevalence at the local level and support resourced targeted interventions co-designed with local areas. Pilot studies could be used to test these approaches (medium confidence)
- A focus on workplace interventions to support Covid-safer practices is important to explore, particularly in small and medium-sized enterprises (SMEs). This could include pilot studies to test the impact of different financial support packages (medium confidence).
- Local public health team interventions should be supported by access to appropriate data to inform and support local decision making (medium confidence)
- Encourage and support co-production of local interventions using community-centred approaches to respond to early indicators of risk (medium confidence).
- Local experience suggests that there may be a disconnect between the communication of changes to advice at the national level, and the need for maintenance of control measures in local areas of enduring prevalence. This can lead to confusion about the guidance by local communities which will not help to reduce the high prevalence in these areas (medium confidence).
- Insufficient financial support and precarious employment are key barriers to self-isolation and getting a test when unwell. Removing financial costs and disincentives is likely to minimise risk factors in areas of enduring prevalence (high confidence).
- As we move from a national lockdown and restrictions to a more localised approach, measures to minimise stigma should be considered at the planning stages of how early indicators of risk are managed. Developing supportive, positively framed communications may counter potential stigma towards areas with enduring transmission (medium confidence).
- Longer term approaches to increase our understanding of these issues include:
 - Multidisciplinary data gathering and case studies could be developed to support a more socially-embedded series of regional interventions based on the experience of combatting other diseases such as tuberculosis and HIV (medium certainty)

- Analysis of community resilience structures between areas that share similar characteristics but have high and low case rates may provide important insights into reasons for enduring prevalence (medium confidence).

The risk factors associated with enduring SARS-CoV-2 prevalence observed in some areas of England

Framing the question

Terminology

Enduring prevalence is a term used to describe a repeating pattern, first identified at the local authority level, of early increasing prevalence of SARS-CoV-2 and a slower decline in prevalence than the surrounding authorities, even in the context of highly restrictive non-pharmaceutical interventions. This pattern can be driven both by higher growth rates in an epidemic upswing, and by slower or no decay concurrently with other areas having strongly declining prevalence, so both prevalence and growth rates are important. . The drivers for high prevalence and/or high growth can themselves be static (e.g. housing density) or dynamic (e.g. changes in interventions). The number of authorities manifesting this pattern may implicate the majority of a region, as has been seen in parts of the Midlands and North of England.

The geographical resolution described in this paper do not likely represent the optimal for the attribution of causation in the patterns observed. This will require further investigation. Neither are the patterns static but nevertheless certain places are regularly evident and have led to prolonged periods of restrictions particularly since early autumn 2020.

Description of the challenge

Areas may come to notice through having high prevalence when prevalence in general is lower, or by being picked up as early indicators of a broader upswing. Looking at this retrospectively to identify areas of concern, there are several different natural approaches. Interestingly, a range of approaches all show largely the same geographic patterns. Figure 1 shows three such approaches.

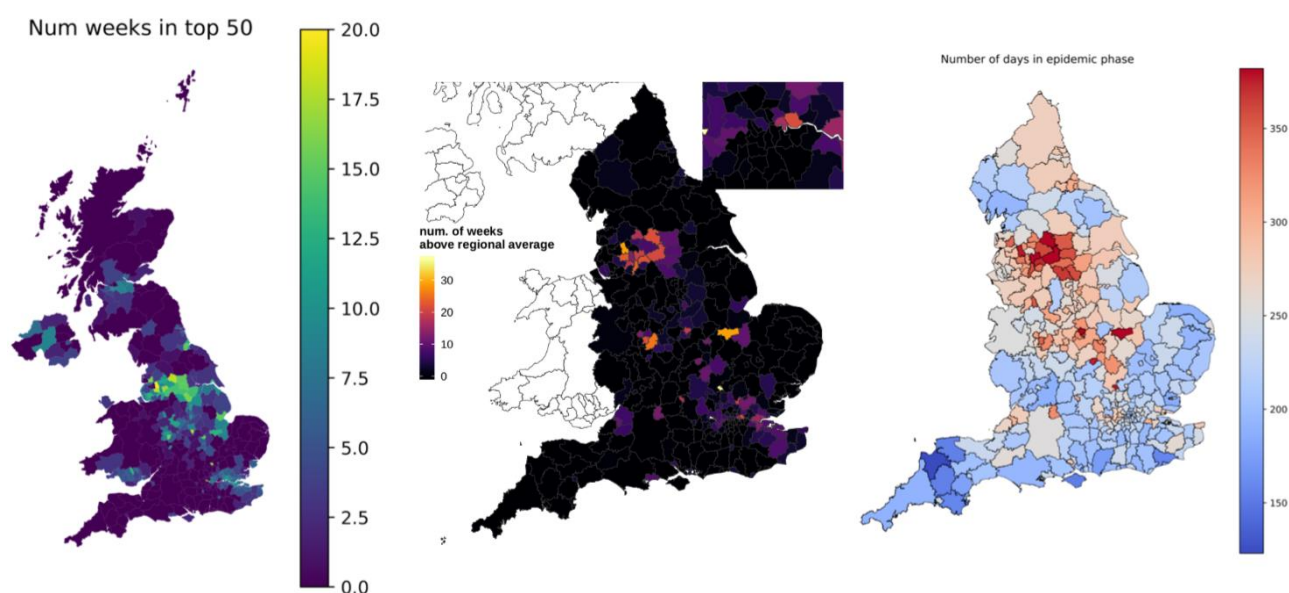


Figure 1: Three different visualisations of areas of enduring transmission: left – by number of weeks in top 50 by prevalence (UK), middle – number of weeks above regional average (England only), right – number of weeks in epidemic phase (England only).

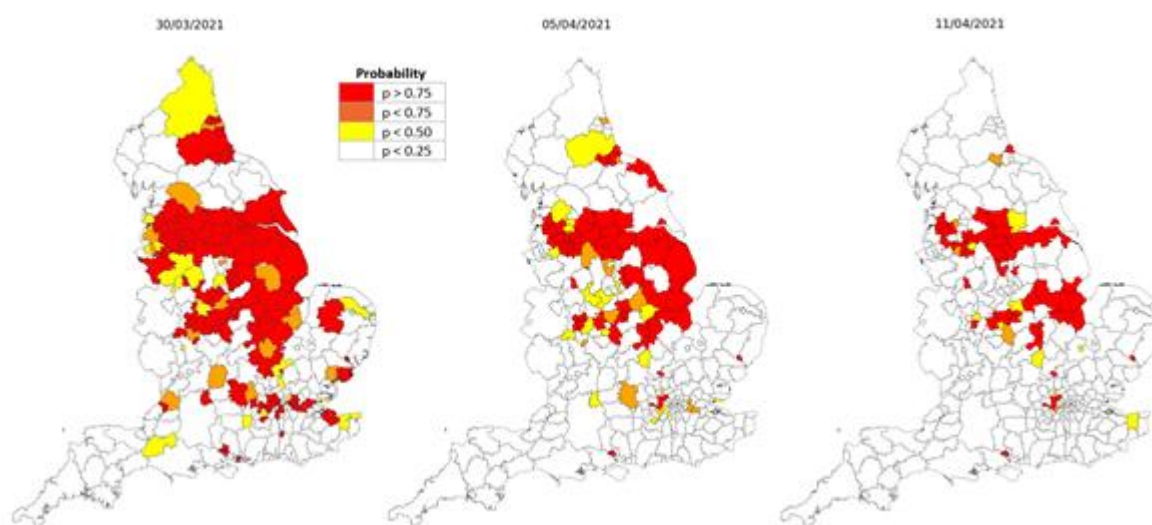


Figure 2. Lower Tier Local Authority Phase Model towards the end of the second wave of the pandemic in England, March – April 2021.

Some of the lower tier local authorities (LTLAs) highlighted in Figures 1 and 2 have also shown common patterns in a steeper exponential rise in cases than other nearby places. These patterns for the places shown Figure 3 are also distinct from that seen in areas of London, the East of England and the South East region where the B.1.1.7 variant established earlier during second wave of the epidemic. The reasons behind the patterns in Figure 3 are consistent with a higher baseline

prevalence during the summer months of 2020 combined with rapid subsequent growth. Disconnect between national communications and local prevalence can lead to misinterpretation of risk which is likely to result in rapid increase in prevalence in some areas. The pattern is particularly evident in Yorkshire and the Humber (Figure 3), but also in some LTLAs of the North West.

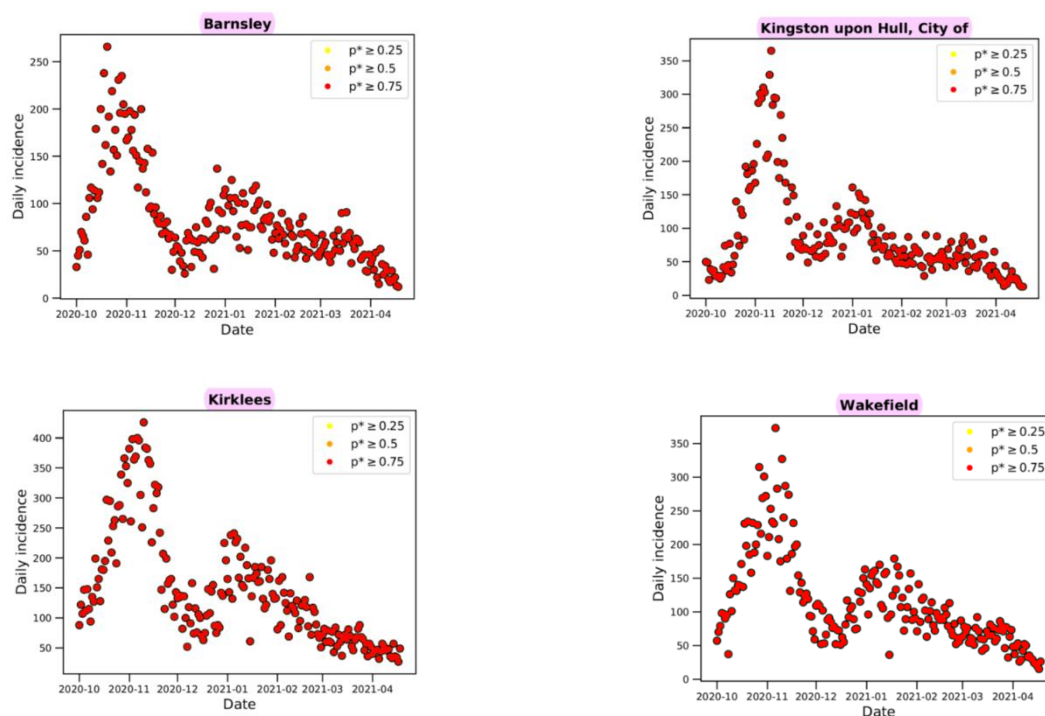


Figure 3: Lower Tier Local Authorities with a high probability of epidemic exceedances. October 2020- April 2021.¹

Framing the problem in relation to geography can be a challenge. For example, Yorkshire and the Humber has an estimated population of 5.5 million inhabitants and includes one county, two metropolitan counties and five unitary districts. The region ranges from very rural areas with sparse populations to dense urban areas; there are 462 built-up areas (or their subdivisions) with 500 inhabitants or more. Each of these areas has (for example) a different demography, population density, ethnic mix, transport infrastructure, mix of industry, and inhabitants move between areas within the region and to other regions for a variety of reasons. The complex interaction of these components within the geographical system in which they are placed means that the disaggregation of the risk factors in any one area of enduring transmission, either large (as the data does not provide sufficient granularity) or small (the data is not sufficient robust) is extremely difficult.

¹ Acknowledgement: Nick Gent, Public Health England.

Developing a Hypothesis.

The initial hypothesis investigated particular geographical locations in England that manifest continued transmission of SARS-Cov-2 in a manner that differed from other geographical locations. The geographical pattern initially suggested a common linked factor or set of factors which could be related to the nature of work in these areas. The specific pattern was a crescent of authorities in the regions of the Midlands, Yorkshire and Humber, and the North West in particular.

As local authorities that spent longest (14 weeks) periods in variations of lockdown in the first and second waves of the pandemic were more deprived than the national average, it was further hypothesised that socio-economic disadvantage was a co-factor in the causation of the continued transmission. (data source: internal CO analysis).

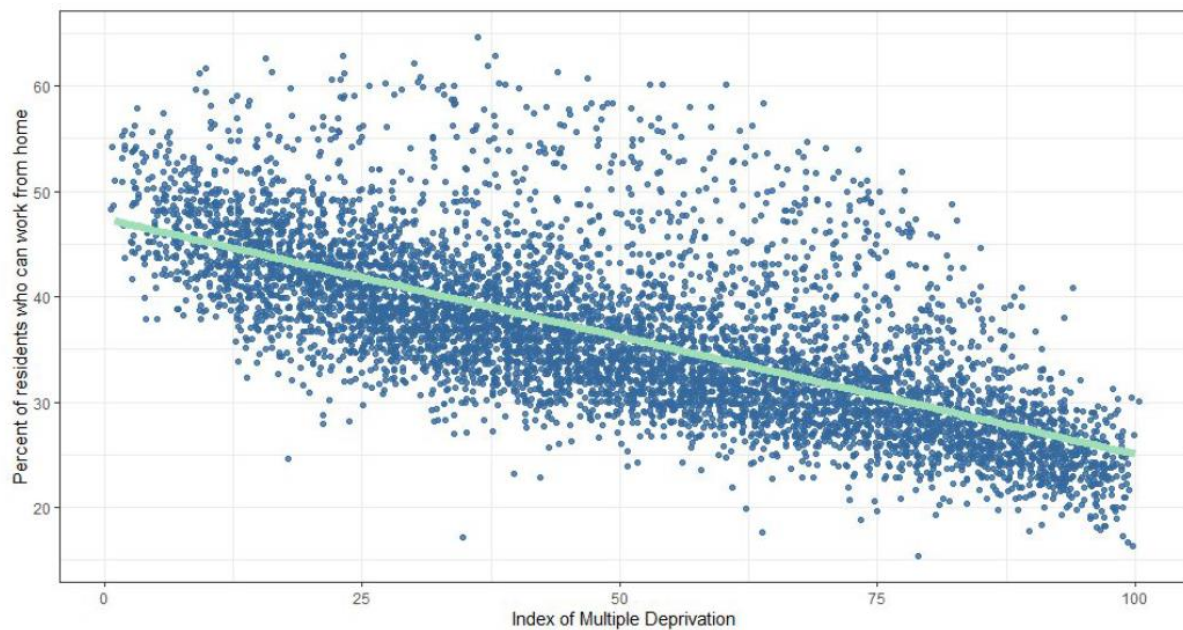
Risk Factors

Employment related Risk Factors

Choice as to where the individual works

The ability to work from home varies regionally. ONS launched the online Labour Market Survey (LMS) in March 2020 which is a survey of around 18,000 households per quarter. Respondents are asked questions on employment, unemployment and economic inactivity relating to a reference week one to two weeks prior to interview. In addition to being asked about their employment status, respondents are also asked if they did any work at home, and if their main reason for doing this was the coronavirus (COVID-19) pandemic. In April 2020, this survey showed that 46.6% of people in employment did some work at home, but that this varied by geography with more than half (57.2%) of workers living in London doing some work from home, while just over one-third of workers living in the West Midlands (35.3%), and Yorkshire and The Humber (37.6%) did some of their work from home (figure 3).

Figure 4 shows the relationship between the index of multiple deprivation and the ability of individuals to work from home, illustrating clearly that within the most deprived areas fewer people have been able to work from home.



Higher value of IMD = more deprived. Each dot is a MSOA.

Source: De Fraja, G. et al., [Zoomshock: The Geography and Local Labour Market Consequences of Working from Home](#), Covid Economics, 13 January 2021; Matheson, J. et al., [Five charts that reveal how remote working could change the UK](#), The Conversation, 2 February 2021

Figure 4: Proportion of people who can work from home by Index of Multiple Deprivation. February 2021.

There are also regional patterns in mobility that indicate indirectly the choices that certain populations have in home working. In Figure 5, London in particular and the South East and East of England regions to a lesser extent show different patterns of mobility relating to work than other regions. In addition, outbreak investigations have demonstrated that some industries (e.g. food processing, distribution warehouses) have high levels of car sharing as the public transport network does not serve the locations where these industries are often sited.

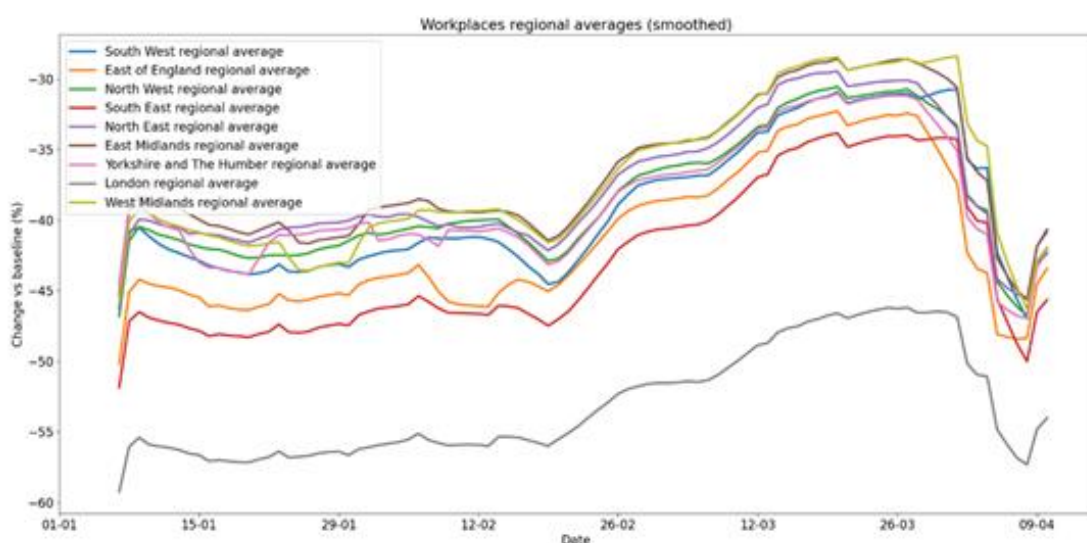


Figure 5(a): Mobility in relation to work. Regions of England, January – April 2021

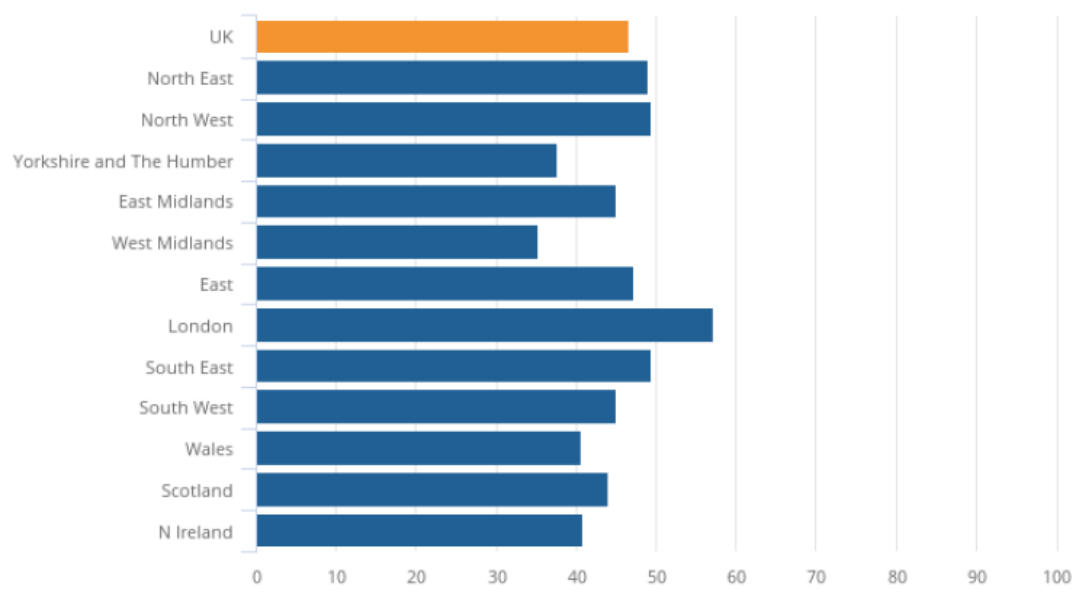


Figure 5(b): Homeworking rates, by region, of those in employment (aged 16 years and over), UK, April 2020
 [Source: Coronavirus and homeworking in the UK: April 2020].

Analysis of workplace outbreak trends has shown correlations between the rates of workplace outbreak occurrence and the infection prevalence rates in the same community (Workplace Outbreak Trends, July 2020 – March 2021, NHS Test and Trace, JBC internal report on 19/04/2021). This may relate to behaviours coming to work and what happens after work, during breaks and even relaxation of wider social interactions.

Regional Employment Patterns

The Proportion of people working in the Manufacturing Sector is highest in six Regions of Great Britain (GB): East Midlands (13.10% of employment), West Midlands (11.85%), Yorkshire and Humber (11.23%), Wales (10.80%), North East (10.58%), and North West (9.33%). All statistics are based on employment figures taken from the Inter-Departmental Business Register (IDBR), extracted in December 2019, and based on Standard Industrial Classifications.

(<https://www.ons.gov.uk/aboutus/whatwedo/paidservices/interdepartmentalbusinessregisteridbr>).

The types of Manufacturing with higher proportions of employment differ by Region. Looking at the 24 SIC Divisions that constitute Manufacturing, the biggest differences in the proportions from the GB average are outlined below, by Region. Italicised entries indicate small numbers of businesses within the Division.

East Midlands (19 out of 24 manufacturing SIC Divisions greater than GB proportion):

- Manufacture of leather and related products (3.75 times the GB proportion)
- Manufacture of wearing apparel (3.66)
- Manufacture of other transport equipment (2.63)
- Manufacture of textiles (2.33)

West Midlands (14 out of 24):

- Manufacture of motor vehicles; trailers and semi-trailers (4.01)
- Manufacture of basic metals (2.29)
- Manufacture of fabricated metal products; except machinery and equipment (2.17)

Yorkshire and Humber (19 out of 24):

- Manufacture of furniture (2.75)
- Manufacture of textiles (2.33)
- Manufacture of other non-metallic mineral products (1.87)

Analysis of workplace outbreak rates has shown consistent high rates of outbreaks in the manufacturing sectors and warehouses in England. These sectors are part of the national key infrastructure and have been in operation throughout the pandemic. It will be important to monitor the workplace outbreak rates in different sectors as the country is moving out of the pandemic and more sectors are increasing their work capacity. The potential links between large workplace outbreaks and the surrounding community transmission warrant further investigation.

Since June 2020, HSE has carried out about 200,000 Spot Checks across GB to support Covid-safer practices. Previous analysis has shown that majority of the businesses (in about 93% of cases) have been able to provide satisfactory assurance that they have appropriate controls in place. Outcomes of the Spot Checks can be analysed by region, sector and enterprise size. These can be linked to the COVID-19 clusters identified from the NHS enhanced (backward) contact tracing for the settings that have been inspected as part of the Spot Check. This will help to understand the regional and sector level disparities in the rates of clusters over time, taking into account the level of controls in place.

The NHS Test and Trace/PHE backward contact tracing data provide information on whether an individual went to work and the place/location of the workplace in the 7 days prior to this individual testing positive for COVID-19. These data can be used to identify clusters of COVID-19 in the workplace across a wide range of settings where there are employees, such as warehouse or distribution, food production and agriculture, manufacturing/construction, retail sector, hospitality, social care, education etc. Analysis of these data could provide information on the number of clusters and the rates of clusters by sectors and geographical area over time. The NHS backward contact tracing data on attending work may be more reliable as they are related to a more stable workers population than the data on visiting different settings which are related to more transient population. Looking at COVID-19 clusters and the potential transmission among workers at the workplace may provide a good indication on the transmission risk in a wide range of settings.

Structural problems within employment and links to geography in English regions

The specific structure and financial situation of businesses is also likely to contribute to increased risk of exposure and attendance at work when unwell. The regions that have been under almost continuous restrictions since March 2020, which continue to have transmission are also areas with a high percentage of SMEs along with manufacturing, which is a better recognised site of transmission. SMEs have faced especially great economic pressures during the pandemic (some of a loss of 80-100% of their income in the first wave)

which make it more difficult for employees and managers to stay at home when unwell and to invest in Covid-safer practices ⁽ⁱⁱ⁾. The financial support offered to them by the Treasury has been in the form of loans or grants based on the corporation tax rateable value of property thereby offering the largest loans to businesses in already prosperous areas. The requirement for personal guarantees (family homes) on some of the bank loans designed for business relief made them inaccessible to some. Some precarious businesses are unwilling to risk taking these loans. In addition, many of them have not benefitted from furlough schemes as they are classed as essential retail or are part of the hospitality sector and therefore have been kept open. The Coronavirus Business Support Grant funding after tax may be consumed by fixed overheads and fails to address lost income. Across a wide range of SMEs the effect of the economic downturn and government support during COVID-19 has been similar—a lack of capital to invest in making businesses COVID-safe or to enable working from home and intense pressures on employees to attend work in person even when unwell. This is increased even further by family obligations in family-run businesses. This impacts some communities more than others. Ethnic minority groups are more likely to run SMEs or family businesses, meaning the risks of transmission will unequally impact their families and communities. Overall survey data shows that SME owners report a lack of realistic sector-specific guidance and support.^[ii]

[i] Bear et al [ARighttoCare-CovidandCare-Final-2310.pdf \(lse.ac.uk\)](#)

[ii] Bear et al [ARighttoCare-CovidandCare-Final-2310.pdf \(lse.ac.uk\)](#)

Other Risk Factors of Relevance to the Workplace

Barriers to testing or to self-isolate when unwell

Self-isolation on symptom onset is one of the most effective means of reducing transmission. A 10% improvement in self-isolation adherence is estimated to reduce R by 11% in low-income areas, and 7% overall. Self-isolation carries a financial disincentive. However, those on lower incomes are much less likely to get a test if they develop symptoms or self-isolate when contacted by NHS Test and Trace (Figure 6). Those individuals on lower incomes are often in more precarious / insecure employments (e.g. agency staff, zero hour contracts, cash in hand) which then result in insufficient financial support. Insecure employment is often low paid, which then results in increased barriers to self-isolation – and therefore reluctance to get a test in the first place, to avoid any legal or financial consequences they can ill afford. Low income workers may be less likely to engage with government systems for several reasons, however an ADPH study (Figure 6)) found that some of the key barriers to self-isolation are:

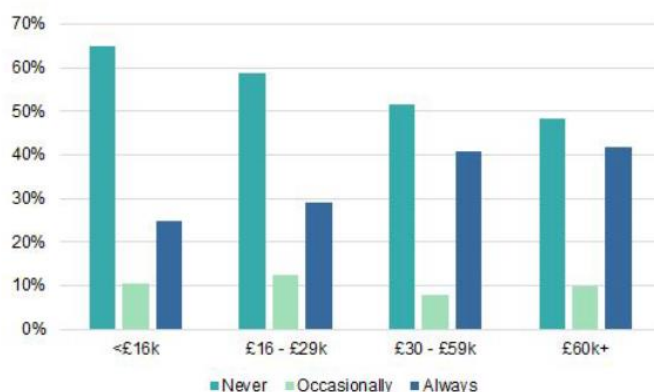
- (1) insufficient financial support;
- (2) insufficient Universal Credit;
- (3) confusion over the rules when advice to self-isolate hasn't come directly from T&T (e.g. schools);

(4) employers withholding pay and encouraging return to work.

People in low income brackets are less likely to request a test if they develop COVID-19 symptoms

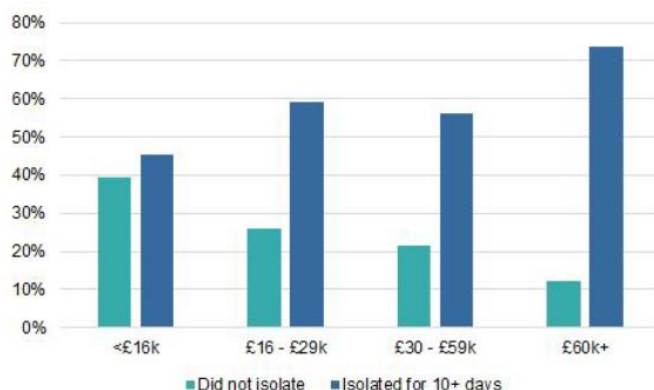
Question: 'Since the start of first lockdown back in March, if you developed symptoms of COVID-19 [a cough/fever/loss of taste or smell], have you requested a test?'

Source: UCL COVID-19 Study (Release 28 - 13 January), n = 7,603



People on low incomes are less likely to self-isolate when told they have been in contact with someone with COVID-19 symptoms

Source: UCL COVID-19 Study (Release 28 - 13 January), n = 2,497



Source: ADPH London, COVID-19, Barriers to Self-Isolation, Response to DHSC request for input to inform future policy development, 11 Nov 2020; JBC, Furlough of cases and their contacts as an NPI; Kucharski, A. et al., [Effectiveness of isolation, testing, contact tracing, and physical distancing on reducing transmission](#), 16 June 2020

Figure 6: People on lower incomes are less likely to get tested and self-isolate.

Some communities have a far greater proportion of workers in low-paid, insecure and frontline roles, this can act as a disincentive to testing and hinder self-isolation; in more deprived areas, reduced financial resilience – and ability to provide financial support – within families and communities is likely to be an additional disincentive to individual's decisions to test and self-isolate.

Previous SAGE papers² have reviewed other risk factors that can provide insight into these areas of enduring prevalence (refs) so they will not be reviewed in detail in this paper. They include:

² SPI-B, Public health messaging for communities from different cultural backgrounds - 22 July 2020, considered at SAGE 48

SPI-B, The impact of financial and other targeted support on rates of self-isolation or quarantine - 16 September 2020, considered at SAGE 57,

Ethnicity sub-group, Housing, household transmission and ethnicity, 26 November 2020, considered at SAGE 70

Ethnicity sub-group, Drivers of the higher COVID-19 incidence, morbidity and mortality among minority ethnic groups, 23 September 2020, considered at SAGE 59

Ethnicity sub-group, Factors influencing COVID-19 vaccine uptake among minority ethnic groups, 17 December 2020, considered at SAGE 73

- Close-knit communities and overcrowded accommodation which include larger family sizes, more multigenerational households and homes of multiple occupation which can exhibit higher rates of transmission;
- Differential impacts due to workplace, housing and community circumstances
- The impact of accessible communications for different communities

When Risk Factors Combine

The risk factors outlined above rarely operate in isolation; indeed, it may be that in areas of enduring prevalence, the risk factors described combine uniquely in particular settings to increase risk. For example, the particular economic structure of these regions may serve as an opportunity for a wide range of risk factors to coalesce in a particular setting which leads to increased opportunities for transmission and can lead to amplification of the impact in the wider system through this combination of risk factors.

The way that national interventions are interpreted by local communities can also help to identify why there may be some specific challenges in implementation to be overcome, and the balance between national direction and local interpretation needs to be considered.

Such socially embedded approaches have been widely shown to be important in combatting other infectious diseases such as Tuberculosis and HIV. Strategies to combat these have moved from solely large-scale medical interventions based on testing and treatment to ones that analyse and engage with the life-circumstances and the social environments of groups and places at risk (Ho, 2004; van Hest et al, 2014) it is likely that a **joined up strategy of national and local** data collection/analysis and subsequent policy interventions would be most effective equivalent to those used to combat Tuberculosis in the EU and the UK PHE Tuberculosis Strategy programme since 2013 (Rocha et al., 2014). These identified the social causes of persistence. They emphasised too the importance of initiatives that cross-cut national, local and NHS boundaries. Link-workers were also seen as crucial at the local level who provided to specific groups-at-risk joined up help with health, social care and occupational issues. Local schemes backed up by resources from central government could address the **social determinants of** COVID-19. Examples from combatting tuberculosis in Peru show that a combination of targeted testing, treatment, community engagement and financial support (in this case cash transfers and micro-credit) are most effective. Policies would need to engage with local **social networks and infrastructures** that influence behaviour based on successful examples of HIV prevention in Uganda, Senegal, Thailand, Brazil, and Australia (Kippax et al., 2012). **Equity matrices** successfully used in relation to other infectious diseases could be deployed to identify and tackle underlying causes of exposure, circulation and barriers to health (Ismail et al., 2021).

Experiences from local Public Health teams

Directors of Public Health have valuable knowledge about the combination of risk factors which emerge in their local areas. For example, understanding the specific nature of the socio-economic structure of a region can provide insights into the links between communities, ethnicity, work,

transport and housing which would not be readily identifiable through any other routes. Many Directors of Public Health and their local public health teams are already engaged in the investigation of local health inequalities and are supporting community engagement, for example through community champion schemes. Variable access to data, concerns about short-term funding and uncertainty around how to evaluate community engagement schemes present challenges for local public health teams (Bear, Kamal ongoing). Investigation of local inequalities and barriers to health could be further supported by data protocols, evaluation of effective measures and case-sharing and longer-term financial resources.

The Experience in West Yorkshire

Not all areas with similar levels of deprivation, demographic and occupational profiles experience higher case rates and mortality. This indicates there are likely to be other factors contributing to the complex interplay of occupational, social and behavioural risk factors. These patterns are illustrated in research on behalf of the West Yorkshire Local Resilience Forum involving the five public teams across the West Yorkshire local authorities. Evidence from outbreak management, local contact tracing and engagement with communities shows that exposure through work is a significant contributor to SARS-CoV-2 transmission during national lockdowns. West Yorkshire has one of the highest levels of manufacturing jobs in the North of England and work in these industries has continued through national and local restrictions. In addition, 99.5% of West Yorkshire businesses are SME employers that employ fewer than 250 staff. Overall, 81% of West Yorkshire businesses are classed as micro businesses, employing fewer than 10 people. These SMEs include small manufacturing units, alongside financial services industries and small scale hospitality and retail. Insight from outbreak management and contact tracing also highlights that in low paid manufacturing and small businesses, employees will only receive statutory sick pay. This impacts negatively on both take up of testing and adherence to self-isolation, especially in those without symptoms. They are also likely to face intense financial pressures to attend work at risk of losing the business (if managers) or losing employment (if employees). West Yorkshire has recommended that there should be more engagement with businesses led by local authority business support teams to make the economic case for investing in outbreak prevention measures and paying statutory sick pay to employees so as to prevent business closure due to outbreaks. But there also needs to be greater central government financial support in terms of Covid-safe grants and instructions for a variety of businesses in how they should work safely. In some areas such as Boston, Lincolnshire community champion networks have also supported such work by focussing campaigns within workplaces (Kamal, Bear research ongoing).

Community Support and Communications

Community led approaches can foster community resilience and enable individuals and communities to take more control over their health leading to better health outcomes. Analysis of community resilience structures between areas that share similar characteristics but have high and low case rates may provide important insights into reasons for enduring transmission.

As we move from a national lockdown and restrictions to a more localised approach, measures to minimise stigma should be considered at the planning stages of how early indicators of risk are

managed. Highlighting positive aspects of the area such as highlighting a community's resilience or, where applicable, working in essential frontline roles to keep the country going through the pandemic may help frame the localised measures in a non-stigmatising wayⁱ.

Data from Greater Manchester suggests many people are informed about COVID restrictions through the TV or national government communications followed by friends and family (see Figure 7 below).

The vast majority of residents find their information on coronavirus and the restrictions in place from TV (88%), followed by national government communications (78%), and friends/family/word of mouth (75%).

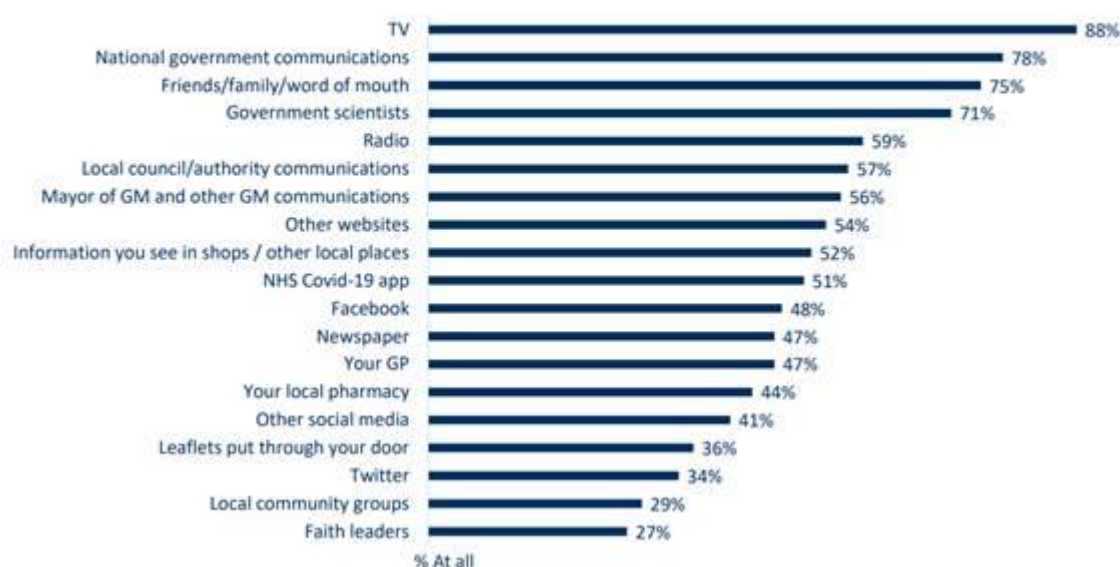


Figure 7: From the Greater Manchester population survey – representative sample of 1000 residents; Safely Managing Covid-19: Greater Manchester Population Survey results - Greater Manchester Combined Authority (greatermanchester-ca.gov.uk) December 2020.

Appropriately tailored communications can support the dissemination of key information as national messages aimed at reducing the risk of transmission may not penetrate to all communities; a higher proportion of these communities may be found in areas of enduring transmission. Barriers to key messages reaching communities includes inaccessible language, modes of delivery and mistrust towards formal organisations that share the messages. A review of communications at a local level may provide important insights into whether or not key messages are reaching the target community in the way that is intended. Previous SAGE reports provide guidance on how to co-produce tailored communications that are more accessible and address the needs of local areas.

Local authorities in areas of enduring transmission reported a communication challenge when the difference between the national and local prevalence was greatest, and different local rules and restrictions were in place. This is supported by some evidence that differences in rules and restrictions in different places (for example on visiting pubs and shops, or how many people you could meet with) leads to more confusion, which in turn could lead to reduced compliance (see figure 8, over). The impact of different national and local rules in areas of enduring prevalence requires further investigation to understand whether this results in changes to behaviour,

compliance, understanding, perception of risk, etc. and to identify appropriate support in these areas.

There is correlation between how clear the guidance is and how well people are thought to be following it

For each piece of guidance, people are more likely to say the advice is clear than to say they think other people are following it well. There is a strong correlation between the proportion of people saying that the Government guidance is clear, and the proportion saying that people are following this advice well. For example, while just over two thirds (68%) believe that the advice on when to stay at home and self-isolate is clear, around the same proportion (64%) believe that other people are following this advice well. This suggests that **greater clarity may aid adherence to the guidance**.

Q. How clear, if at all, do you think the official guidance is on each of the following areas? / And how well, if at all, do you think that people generally are following the official Government guidance on each of the following areas?

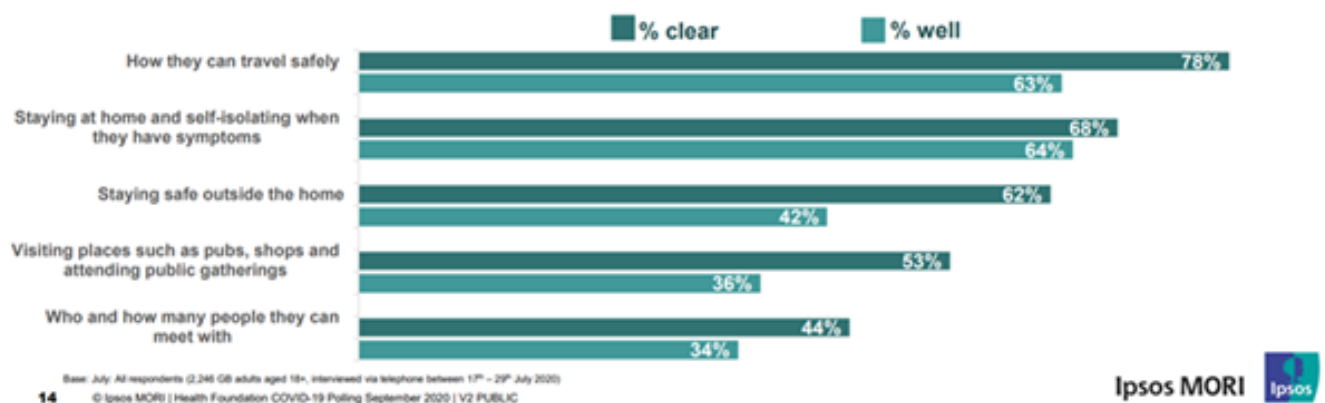


Figure 8: Information from Ipsos MORI linking clarity of messaging with compliance/adherence.

With increasing proportions of the population being vaccinated, and as we progress along the national roadmap and lifting of restrictions, there is likely to be a reduced perception of COVID risk, which could result in lower compliance with remaining rules and restrictions. This may have greater consequence for areas of enduring transmission, if they continue with higher than national prevalence levels and ongoing structural risks of transmission.

A recent SPI-B report indicated that if strict restrictions are retained for months and eased and people are told it is safe to resume a number of previously restricted activities, they will expect this to mean the risk of infection has reduced. In areas of enduring prevalence where restrictions may be retained, clear communications will be required along with appropriate support to minimise psychological, social and financial harm.

The use of measurements and modelling to identify the emergence of new areas of enduring prevalence, or changes in existing areas.

Waste-Water Sampling

Routine analysis of wastewater (WW) samples for infectious disease surveillance has gained significant attention recently, due to its demonstrated utility in monitoring the COVID-19 pandemic, (Medema *et al.*, 2020). Led by the Joint Biosecurity Centre and Defra Group under the Environmental Monitoring for Health Protection programme (EMHP), wastewater-based epidemiology (WBE) for

SARS-CoV-2 has been operational in England since July 2020 and internationally (European Commission, 2020).

Wastewater samples collected from sewage treatment works (STW), in-network sites, and near-to-source infrastructure sites currently provide coverage of over two-thirds of the English population. STWs typically serve larger catchment areas, up to 3 million individuals, and account for a larger proportion of the population. In-network sites provide insight at lower-level geographies, typically mapping to LSOAs and drawing sewage from smaller populations, but have predominantly been established in large urban areas. As repeated sampling is carried out at the same locations, wastewater data can be visualised as a timeseries and deviations from national, regional, and historic local averages identified, which may indicate communities experiencing enduring transmission or entering a period of enduring transmission.

Additionally, faecal shedding has been found to peak early in the disease course (Miura et al., 2020). Wastewater monitoring is therefore able to capture both asymptomatic and pre-symptomatic infections that may be unaccounted for in clinical data due to testing policies.

Therefore, in settings where enduring transmission is caused in part by a reluctance or barriers in accessing SARS-CoV-2 testing, wastewater monitoring may detect an upwards or constant trend in viral RNA concentrations further in advance of clinical testing, or indicate more widespread transmission.

Modelling Approaches

Recent work by SPI-M has developed methods of identifying accelerated change in populations which may have relevance to both places where enduring transmission is likely and those where unexpected change (for example resulting from variants) is occurring in forthcoming phases of the pandemic.

Figure 9 shows the two-dimensional phase space with growth rate on the horizontal axis and prevalence on the vertical axis. Local authorities are shown as squares, with a tail running back over previous days. The colour of the square indicates average IMD rank (lighter is higher). Prevalence here is given as a (smoothed) proportion of positive pillar 2 samples from Monday 12th April and the previous 14 days. Similar patterns can be generated from number positive.

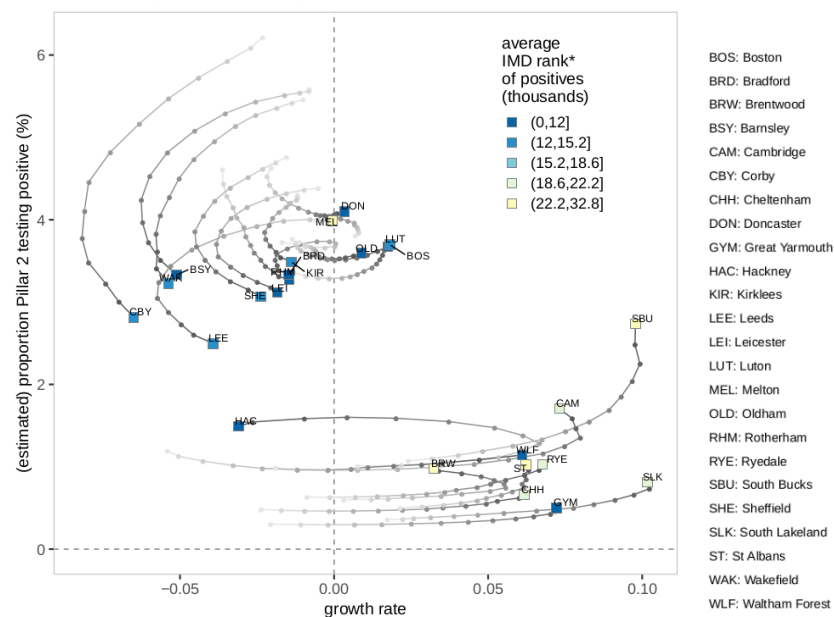


Figure 9: Identifying current places with high prevalence (top part of plot) or high growth rate (rightmost part of plot).

More detail regarding the modelling approaches is provided in an annex 2.

CONCLUSIONS

1. The geographical pattern initially suggested a common linked factor or set of factors which could be related to the nature of work in these areas. This investigation has not supported the hypothesis fully, but has identified that the workplace may contribute as part of a complex interplay of factors driven predominantly by social and economic disadvantage in areas of enduring prevalence.
2. The interplay of these factors in these areas is not fully understood, nor is the reason why other areas of high deprivation do not demonstrate enduring prevalence in this epidemic. The authors would wish to pursue more hypotheses testing to examine data from areas demonstrating both patterns during the epidemic.
3. The combination of local and regional practitioner combined with specialist inputs to this work has been fruitful, and the group that have co-authored this paper wish to continue to work together. We particularly support testing of interventions locally that support populations who need to comply with workplace and wider regulations to do so and evaluate whether this can alter the course of any increase in cases, in locations of enduring prevalence. As these areas are known, it is possible to identify pilot sites with the agreement of local public health leaders.
4. Further research could examine the utility of the models in Figure 7 in providing early warning and earlier interventions should prevalence begin to rise in the remaining phases of the pandemic. This may have further utility for outbreaks in the future.

Recommendations

If we look at trends over time from the peak of the second wave some of these districts' current high level represents a great improvement on the numbers at their peak (for example Blackburn in Darwen) and the high numbers of continuing cases are due to the extensive transmission earlier in the pandemic as a residual effect. This is potentially concerning as some modelling indicates that large outbreaks and residual transmission after interventions are the best predictors for future outbreaks. Overall, it is likely that places of enduring transmission will be identifiable from these current patterns cross-referenced with social deprivation indices and data on vaccination uptake. It will be important for public health teams to track these at ward level within each region in order to identify pockets of inequality in enduring transmission.

One aspect not included is the geographical scale of policy. Part of the reason for the problems in NW is that national relaxation of NPI in June 2020 was too early – the prevalence in NW was higher than SE. Exponential growth magnifies the differences so that up-sooner, down-later patterns are largely driven by exponential growth/decay cycles starting from a higher prevalence. Tailoring policy changes to local circumstances would be one approach (but isn't in the roadmap)

A focus on interventions in workplaces including not just manufacturing, but also SMEs of all kinds, to support Covid-safer practices is important to explore. Financial constraints are greater for these, limiting the ability to pay sick pay, introduce home working equipment (where possible) or invest in Covid-safer workplaces. Alongside this family business structures and financial precarity make it difficult for employees to stay away from work when unwell. We recommend further research and recommendations on making SMEs in areas of persistent transmission Covid-safer. This could include, as in Boston, Lincolnshire community champions focussed on workplace change alongside, as in Leicester collaborations with unions and local business associations. At the national level it may be important to address SME Covid safer support schemes in Treasury plans and for the Health and Safety executive to address SME Covid-safe practice guidance and inspections in specific regions.

Overall an approach that combines qualitative and quantitative data, shared between area public health teams and national level decision makers, is important to reveal patterns that include social factors. Alongside this a central online resource of successful local interventions could better inform central decision making at the Cabinet Office level.

At the national level it is likely that given the correlation of occupational and social disparity with enduring transmission a Covid-safe legal framework for businesses and housing would be helpful to deal with underlying causes. There is some evidence financial support for social isolation, legal entitlements to sickness and/or vaccination leave would be effective tooⁱⁱ, ⁱⁱⁱ.

Regional and local Directors of Public Health have substantial knowledge about the reasons why there are particular challenges in some areas and it is important to both effectively capture this knowledge to support local, regional and national strategies, and provide effective resource to support these areas in effectively managing enduring transmission.

Further consultation with regional public health directors would be helpful in developing protocols for rapid action research. However, recent research on local authority pandemic policies shows a responsive community oriented **feed-back process** of **discovery, design and implementation** is likely

to be successful (Bear, Kamal ongoing). Local public health teams looked at inequality and transmission data across various parameters; engaged with community forums and local authority planning and business teams in collaboration with local NHS care trusts. Outreach and data gathering was also carried out with voluntary, third sector organisations and unions. On this basis existing or new community champion schemes were developed to create engagement and information feedback on key interventions. These schemes were very diverse in form depending on the local issues faced. They focussed on employment settings, particular communities or wards depending on data on vaccination and transmission. Early evidence indicates this approach can address the barriers of stigma and mistrust by empowering communities, with appropriate resources and support from local authorities, to generate localised solutions to enduring transmission. As a general principle key questions need to be asked and checked against data sources about whether workplaces, housing, social networks or barriers to health seeking should be targeted as a priority. This questioning could reflect on questions of **ease**, likely **effectiveness** and **equity of interventions**.

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Annexe 1 (CTAS Backwards Tracing Data)

Backwards Tracing CTAS data: Methodology, coverage, and Insights

Methodology

Contact tracing service data (CTAS) provides insights into where potential transmissions are occurring^[1]. The JBC team works with backwards contact tracing data, covering the period from 7 to 2 days pre-test or symptom onset, to map likely transmissions by geographical location and setting type. CTAS data is processed into clusters of transmissions using an algorithm based on three criteria utilised to define a cluster. The criteria for a cluster to be detected are that 2 or more transmissions have occurred within a 6-day window, in a postcode containing up to 1 degree of separation, and that share the same exposure setting type.

Potential insights from BT-CTAS data

Process insights: wider literature

CTAS data provides insights into both the type of settings in which transmissions are occurring against different non-pharmaceutical interventions over time and into system engagement. As a key method of disease control, extensive work has been undertaken to understand engagement with the contact tracing system in the UK. This research has surfaced some important areas around how system engagement could be further investigated and improved. Areas for further improvement include communications around understanding the symptoms of covid-19, the isolation period, the need for double tests, the scheduling of second tests and expected behaviour during the isolation period (Smith *et al* 2021).

There were also many incidences where cases and contacts reported being willing to isolate but unable to afford to do so. A recent study of 175 local authorities revealed that 7 in 10 applicants did not receive financial support for self-isolation. The study concluded that 40% of workers would have to go into debt, or go into arrears, if their income dropped to £96 a week – the current level of statutory sick pay (TUC, 2021). The fear of losing employment was another major concern amongst respondents. Yang Hu concluded that ethnic minority groups migrants 3.1 times more likely to lose their jobs during the COVID-19 lockdown than UK-born white British (10.1 % vs. 3.3 %, F [between-group difference] = 9.09, $p < 0.01$). The highest risk was amongst Bangladeshi and Pakistani groups due to the high rates of self-employment and single-income earner households (Hu 2020). A further data blindspot are asylum seekers and seasonal or migrant workers, against disqualified from any type of financial support for self-isolation. The Pew Research Center estimated that at least 800,000 to 1.2 million unauthorized immigrants lived in the UK in 2017 (Pew Research centre 2017).

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- [Adherence to the test, trace, and isolate system in the UK: results from 37 nationally representative surveys | The BMJ](#)
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- [Intersecting ethnic and native–migrant inequalities in the economic impact of the COVID-19 pandemic in the UK - ScienceDirect](#)
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Input from wider T&T work (Bella Grant):

Feedback directly from >1,000 clinical contact tracers was collated over a period of eight months (Jun-22 to Feb-21) to support the more rapid turnaround of reported issues and enhance the efficiency of the Tracing system^[1].

Key issues highlighted:

- Lack of financial support or caring responsibilities making isolation difficult;
- Communication issues (translator protocols);
- Repeat self-isolation mandate on repeat positive test;
- Pandemic fatigue;
- Multiple T&T calls per person/ per household;
- Lack of trust in the T&T system;
- Low visibility of Public Health campaign advertising the official T&T number (calls from unknown 0300 number);
- Technology failures of the T&T system – especially when citizen tried to self-complete tracing, but also when contact tracers on calls to citizen;
- Insufficient support to enable fully functioning workforce;
- Conflicting advice with regards isolation end-dates – T&T vs. Covid App;
- Symptomatic citizens too ill to receive call.

Internal JBC qualitative insights:

In order to better understand the CTAS data coverage, the JBC Cluster Detection Team conducted a round of in-depth interviews with five clinical contact tracers in April 2021. Contact tracers reported that in the main, the majority of cases contacted were compliant and no regional differences were noted in case compliance from within the sample (please note the small size was selected for more in-depth interviews). Reported challenges confronted in obtaining information varied by age group. Younger individuals (<30) with higher levels of social mobility and less a sense of routine, struggled recalling their movements. This was particularly the case during times where hospitality and non-essential

retail was open. Older individuals (>40) struggled more with identifying postcode data but had a more definite sense of times and places visited. Those with a language barrier were also flagged as finding the process challenging and were not always able to provide the right information.

In line with the wider literature, individuals who are less financially secure were reported to be more hesitant towards system engagement. This was reported to be due to the fear of job loss. Some older people were also reported to be suspicious of disclosing personal information, this is presumed to be linked to the relatively high level of fraud during the covid-19 pandemic. There was further hesitancy to engage among people residing in larger households (10+) or students in shared accommodation. This was reported to be due to frustrations around repeat requests to disclose information as further positive cases are identified, particularly in student hall or classroom settings. Individuals in larger households also experience overlapping and complex self-isolation periods.

Sources of hesitancy among international travellers was associated with the high numbers of in this group being asymptomatic. A further category of international travellers identified were HGV drivers transporting goods. This group are generally unfamiliar with the UK T&T system and objectives. International HGV drivers often require a translator and have a complicated backwards tracing history (consisting of multiple stops, contacts, and locations across several countries). Some have been reported to be entering the UK whilst symptomatic.

CTAS quantitative insights by setting type (January to March 2021):

The predominant two core exposure settings are supermarkets and educational institutions. Transmissions in educational settings such as primary and secondary schools increase rapidly between national lockdown periods and may be considered as a potential driver of transmission. Healthcare was also identified as a prominent setting for transmission being only relatively lower in London, the East Midlands, and Yorkshire and the Humber (over the period from 1st January to 31st March 2021). Supermarkets feature as the highest setting types for transmission across all intervention types and seasons. Supermarkets have been identified as a potential key transmission setting type in London, the East Midlands, the West Midlands and South West, over 2021 to date. Occupation (excluding health, supermarkets, schools, social care) is a further important setting type in London and the East Midlands. It should be noted that this category requires further breakdown and is assumed to predominantly relate to office settings, the proportion of construction workers in this category was noted to be relatively small). Transmissions reported in warehouse settings were found to be more prevalent in Yorkshire and Humber and the East Midlands.

^[1] Shared with Steve McManus (Head of Trace, T&T), Michael Brodie (Interim CE, PHE) and Lord Bethell (Parliamentary Under-Secretary, DHSC). The focus of this internal report was to voice Clinical Contact Tracers' feedback directly to the T&T Leadership team

^[1] Backward tracing contact data covers the period from 7 days up to 2 days before a test or symptom onset. Due to the incubation period for Covid-19, 2 days is presumed to be post-infection.

**Defining “enduring prevalence”
SPI-M spatial variation subgroup
21st April 2021**

Summary

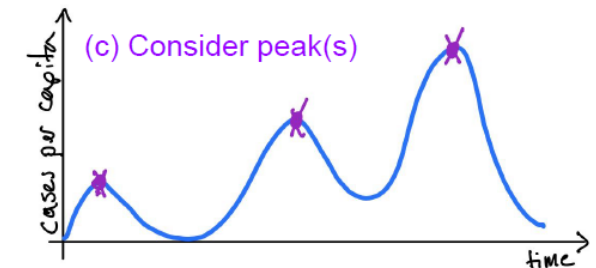
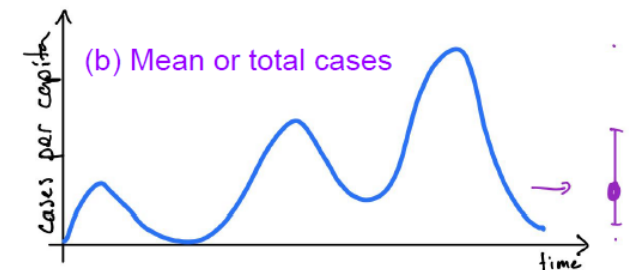
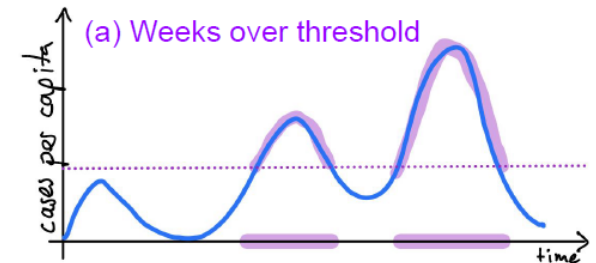
These slides are compiled accompany the paper from the Regional Variation subgroup of SAGE on understanding factors that lead to enduring prevalence. Here we focus on identifying which regions these are from epidemiological data. There is not a single agreed quantitative definition of “enduring prevalence” and there are a variety of plausible candidates. A range of approaches are applied by groups to the UK or England data below. While there are some small differences in precisely which areas are identified, the broad patterns are similar between all approaches, suggesting “enduring prevalence” is relatively robust to different choices of quantitative definition. Note these considerations here are separate from “early warning” work: identifying places where there is a projected increase in prevalence not consistent with past patterns.

Some possible definitions:

Translating from a verbal description “enduring prevalence” or areas of “persistent transmission” or “long term concern” to a quantitative metric brings a number of choices. Here we present some options.

- (a) Number of weeks over a threshold
 - *may best identify first-up-last-down*(this threshold could be in terms of weekly cases per capita, ranking in top X, or weeks in “epidemic phase”)
- (b) Mean prevalence over time (or distribution) or total cases
 - *places that consistently run “hotter”*
- (c) Peak value(s)
 - *places where local patterns mean epidemic can spike*

In addition, these can all be considered in further detail by separating further in terms of timescale such as over a wave. Further, focussing within a smaller geography will show which places are outliers locally, which may help yield broader insights in what factors are behind “enduring transmission” by multiple comparisons across a set of regions.



These certain aren't all the possibilities, e.g. could use steepness of increase and other measures involving R/growth rates.

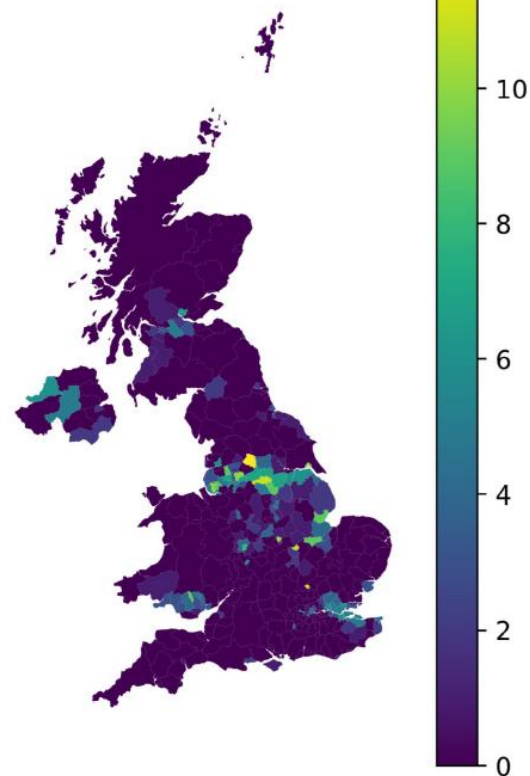
Lancaster -- Top k LADs by incidence

- “Incidence rank” is defined as the rank of each LAD ordered by positive test incidence per capita.
- Persistence is defined as the number of weeks between 1st October 2020 and 19th April 2021 that each LAD’s Incidence Rank has appeared in the top k rankings.
- Ranking LADs by positive tests per capita automatically adjusts for changing incidence over time, and helps to prevent artefacts due to different peaks occurring at different times.

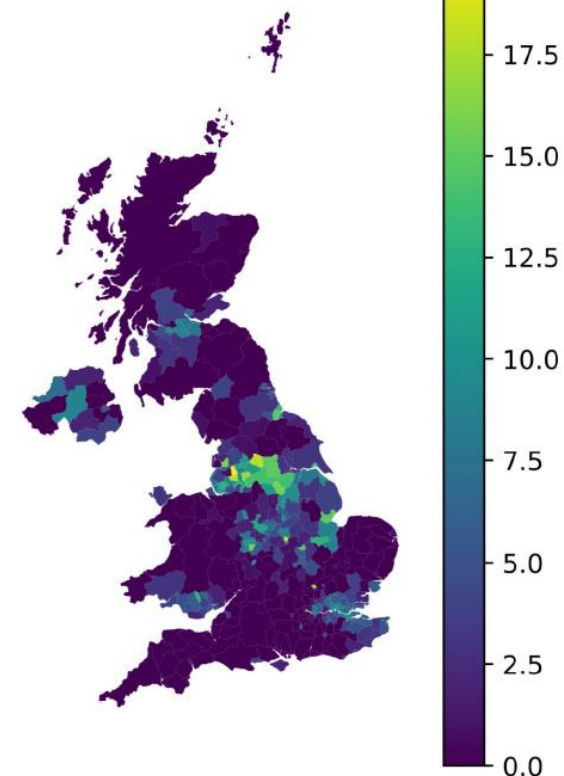
LAD	Num weeks in top 20
Bradford	12
Corby	11
Barnsley	11
Luton	11
Leicester	10
Knowsley	10
Rochdale	10
Hull	10
St. Helens	9
Merthyr Tydfil	9

Top 10 LADs by number of weeks in top 20
Incidence Rank

Num weeks in top 20



Num weeks in top 50



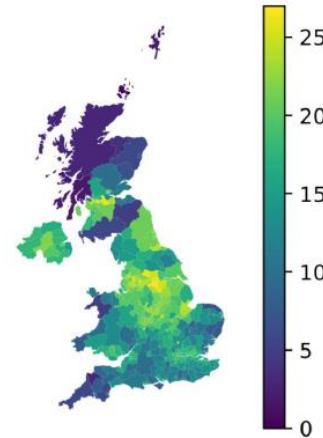
Lancaster -- incidence thresholding

- LADs are coloured by number of weeks between 1st October 2020 and 19th April 2021 in which positive test incidence per capita exceeds 100, 200, 300, and 400 cases per 100,000.
- Persistence is shown best for the 400 cases per 100,000 threshold.
- Artefacts are introduced in sparsely population areas (e.g. Eden, Copeland, Breckland) due to differing epidemic peak timings relative to the overall UK total incidence.

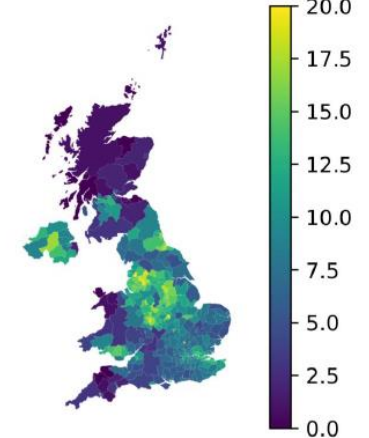
LAD	Num weeks > 400/1e5
Pendle	11
Burnley	11
Blackburn with Darwen	11
Thanet	10
Swale	10
Medway	9
Knowsley	9
Hyndburn	9
Merthyr Tydfil	9
Blaenau Gwent	9

Top 10 LADs by number of weeks above 400 cases per 100,000.

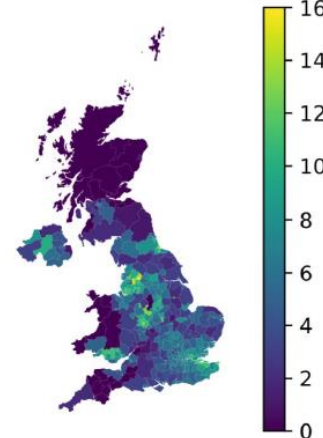
Num weeks > 100 cases/1e5



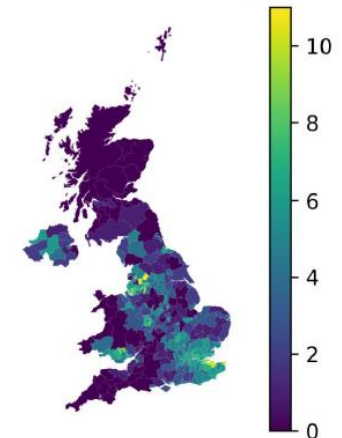
Num weeks > 200 cases/1e5



Num weeks > 300 cases/1e5



Num weeks > 400 cases/1e5



Warwick

Definitions of local authorities of 'long term concern'

The local authority is labelled as 'long term concern' if the following measure is above a given threshold:

Case I: Number of weeks that the (smooth) proportion of Pillar 2 positive tests in a local authority is above England's average with (estimated) probability 1.

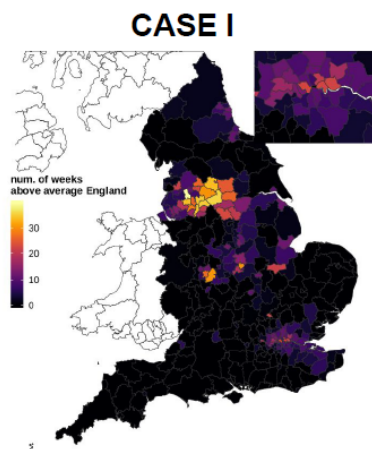
Case II: Number of weeks that the (smooth) proportion of Pillar 2 positive tests in a local authority is above the regional average with (estimated) probability 1.

Method

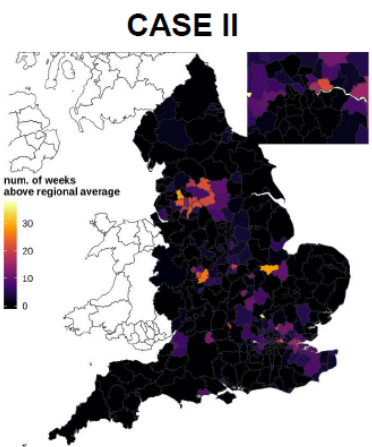
Model: The proportion of positive Pillar 2 samples per day per local authority is fitted using a beta-binomial distribution and a Gaussian Process (GP). For a fixed day, samples are generated from the posterior distribution of the GP to estimate the probability of a local authority being above average $P(x_{it} > \text{mean}(X_{it}))$.

Dates: 01 June 2020 - 13 April 2021

***Average IMD rank:** Average IMD rank of people with positive swabs.



	Local Authority	Number of weeks	Region	Average IMD rank*
1	Blackburn with Darwen	39.7	North West	8462
2	Kirklees	35.7	Yorkshire and Humber	12250
3	Oldham	35.0	North West	9366
4	Rochdale	34.7	North West	9109
5	Manchester	34.6	North West	6268
6	Bolton	34.0	North West	10939
7	Bradford	33.7	Yorkshire and Humber	7862
8	Birmingham	30.6	West Midlands	6957
9	Leicester	30.3	East Midlands	9907
10	Calderdale	30.3	Yorkshire and Humber	12257
11	Salford	28.6	North West	9532
12	Sandwell	26.7	West Midlands	7318
13	Pendle	26.1	North West	9390
14	Bury	26.0	North West	14632
15	Wakefield	26.0	Yorkshire and Humber	12411
16	Leeds	24.9	Yorkshire and Humber	13062



	Local Authority	Number of weeks	Region	Average IMD rank*
1	Slough	36.6	South East	12998
2	Luton	35.7	East of England	11287
3	Blackburn with Darwen	29.0	North West	8462
4	Peterborough	29.0	East of England	10664
5	Birmingham	25.4	West Midlands	6957
6	Manchester	23.7	North West	6268
7	Bolton	23.1	North West	10939
8	Oldham	22.3	North West	9366
9	Sandwell	22.0	West Midlands	7318
10	Bradford	21.9	Yorkshire and Humber	7862
11	Newham	21.7	London	8695
12	Kirklees	21.0	Yorkshire and Humber	12250
13	Rochdale	20.0	North West	9109
14	Leicester	19.4	East Midlands	9907
15	Broxbourne	19.1	East of England	16989
16	Salford	18.7	North West	9532
17	Oxford	17.7	South East	16946
18	Pendle	17.6	North West	9390

PHE

England map showing the number of days since 1st March 2020 that each local authority has spent in the epidemic phase.

This output comes from a hidden Markov switch model that uses reported case data to assign a probability that each local authority is 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.

The ten local authorities with the highest number of days spent in the epidemic phase are:

Peterborough
Bradford
Kirklees
Rochdale
Leicester
Luton
Blackburn with Darwen
Northampton
Oldham
Sheffield

