11 February 2021

EMG – Transmission Group

COVID-19 Risk by Occupation and Workplace

1. Purpose and Scope of Paper

This paper explores the current evidence base with respect to the risks of COVID-19 infection and mortality by occupation, which may provide an indication of the risk of the virus transmission in workplace settings. The paper should be read with a number of caveats:

- Transmission is a continuous risk which can occur in any setting (including but not limited to the workplace);
- Work-related exposures have been modified over time by NPIs and lockdowns, and data from some occupations and workplaces is sparse as they have been subject to significant restrictions;
- Evidence from a range of studies needs to be synthesised to understand the complexity of transmission; all have their limitations and biases. The majority of evidence describes associations rather than causation;
- It is extremely difficult to determine how much of the transmission of SARS-CoV-2 takes place within the workplace, and how much is associated with related social, household or transport exposures;
- There is variation in the extent, quality and level of adherence to COVID secure measures within and between workplace settings. Detailed analysis of these variations cannot be readily drawn out from available data.

The paper describes risks of transmission, and mortality, within occupational groups. It is important to note that this is not analogous to the contribution that the sector within which such occupations exist makes to transmission or mortality at population level. It is also important to note that a number of occupations may combine within a single workplace (e.g. security guards, office workers, machine operators, accountants) which makes interventions targeted at single occupations extremely difficult to implement effectively.

The paper does not address school settings which are being dealt with separately.

2. Key findings

- **Age is the highest risk factor associated with mortality from COVID-19 (high confidence).**[1]

- **Transmission risk is a complex combination of environmental and human factors that are associated with the likelihood of infection**[2] **(high confidence) (see also Table 7). There is a clear interplay between occupational risk of SARS-CoV-2 transmission and socioeconomic inequities, which reflects the amplifying effects between the working environment, crowded housing, job insecurity and poverty. Factors affecting transmission include but are not limited to:**
    - Length and frequency of exposures (time);
    - Proximity or physical contact with an infected individual (non-linear relationship with distance);

  - Number of people within a space (likelihood of presence of an infectious person and greater potential for secondary cases);
  - Infectiousness of individuals, which may differ between viral variants;
  - Emission rates of virus which vary between people and with vocal activity;
  - Ratio of virus transmitted through close-range droplets, longer range aerosol particles and on surfaces (not known but likely to differ between settings and individuals);
  - The use and efficacy of controls within each setting, including ventilation, social distancing, hygiene measures and other appropriate approaches. In a work setting this should be determined by a risk assessment using the hierarchy of control;
  - Socioeconomic factors (which influence ability to self-isolate, household size).

- **All occupations comprise a number of discrete but linked activities (e.g. travel to work and associated social activities). Each of these activities has a different risk requiring effective protective controls and preventative mitigations to be in place to manage them. In addition, transmission is a continuous risk and can occur in any setting or the interfaces between them (high confidence).**

- **Within sectors that have remained active during lockdown, evidence shows that people who work in some specific occupations and roles have increased risks of being infected, hospitalised or dying prematurely. This is higher in many occupations where people have to attend a workplace compared with people in occupations who can work from home (high confidence).**
  - It is challenging to determine how much transmission takes place within the workplace, and how much is associated with related social, household or transport exposures (medium confidence).
  - It is challenging to identify from most existing studies what parts of the risk could be mitigated through a change in infection prevention controls (medium confidence).

- **Requiring more people to come to a workplace is likely to increase the risk of transmission associated with that workplace (high confidence). People attending the workplace while unwell (more likely if not provided with sick leave or financial compensation) increases the risk of transmission in the workplace.** Different occupations, and different levels of autonomy with respect to decision making in a workplace, have differing ability to work from home (high confidence). This may also vary with different cultural expectations across different socioeconomic or ethnic groups.

- **Occupations which involve a higher degree of physical proximity to others over longer periods of time tend to have higher COVID-19 infection and mortality rates (high confidence).**

- **Compliance with required control measures in work environments contacted by HSE appears high (medium confidence).** Compliance is dependent on many factors including leadership, organisational culture and other behavioural factors including the maintenance of control measures at the interfaces of work activities (e.g. canteens, post-work contacts, smoking areas, shared transport).

- **Increased risks in those employed in certain occupations may be due to workplace factors (e.g. lack of ventilation, lack of PPE, etc) or factors outside of the workplace (e.g. socioeconomic inequalities, household size and financial barriers to isolation), which increase individuals' risk of infection (high confidence).**

- **Regardless of the source of the initial infection, the risk of onward transmission also relates to working, traveling and living conditions; for many occupations, it may be difficult to disentangle these effects (medium confidence).**

Although it is beyond the scope of this document to assess the effectiveness of different interventions in reducing occupational risk, there are a range of potential approaches that could be considered. Interventions should follow a hierarchy of control and it is likely that a combination of measures are required, which includes, but is not limited to:

- **Encouraging businesses to support more people to work from home; noting that ONS data on the number of people who report going to their workplace at least one day a week when they could work from home full time is 25%.[3]**
- **Fiscal interventions to enable people in all occupational groups to self-isolate if symptomatic or if contact of confirmed cases.**
- **Workplaces should keep their risk management systems under review as new evidence and good practice emerge, including the controls they have introduced to provide a "COVID-19 secure" work environment (based on the hierarchy of control). In addition to the physical controls required, it should also consider behavioural issues to ensure adherence to the measures implemented.**
- **Provision of safe self-isolation space if living in crowded household or shared accommodation with no ability to self-isolate or living with vulnerable adults.**
- **Fiscal interventions to allow more people who are not part of core essential services to work from home during periods of intense virus transmission.**
- **Supporting employers to enable full application of work-based modifications to make workplaces more "COVID-19 secure".**
- **Effective communication of the risks and expectations, particularly communications focused on the responsibility of employers (rather than the public) and strategies by which they can support employees and their community.**
- **Regular asymptomatic testing particularly in high-risk occupations within the context of a risk management strategy, that is also linked to supported isolation.**

3. Framing of the challenge with respect to occupation as a risk in transmission

This paper is a summary of the best available evidence at the time of writing with respect to the risks of COVID-19 infection and mortality by occupation, which may provide an indication of the risk of the virus transmission in workplace settings. It draws together evidence from Public Health England (PHE), the Office for National Statistics (ONS), the Health and Safety Executive (HSE) and places these in the context of several other published analyses.

Evidence from a range of studies needs to be synthesised to understand the complexity of transmission, and to attempt to assess to what extent any increased risks are due to workplace factors and/or to factors outside of occupational transmission independent of exposure in other settings. Given the heterogeneity of the methodological approaches, each study contains its own caveats and limitations, and caution should be applied in assessing the precise level of risk associated with each occupational or workplace setting. In general, it is extremely difficult to determine how much of the transmission of SARS-CoV-2 takes place within the workplace, and how much is associated with related social, household or transport exposures. Moreover, the differences in study design, methodology and analysis make comparisons between studies difficult.

Data from some occupations and workplaces is sparse as they have been subject to more significant restrictions, and there is variation in the extent, quality and level of adherence to COVID secure measures within categories of workplace settings. This level of detailed analysis cannot be drawn out from available data. Nevertheless, we aim to identify where there are multiple strands of evidence that suggest increased risks of COVID-19 infection associated with specific occupations or risk of transmission with workplace settings.

Key considerations that need to be considered when reviewing the data are:

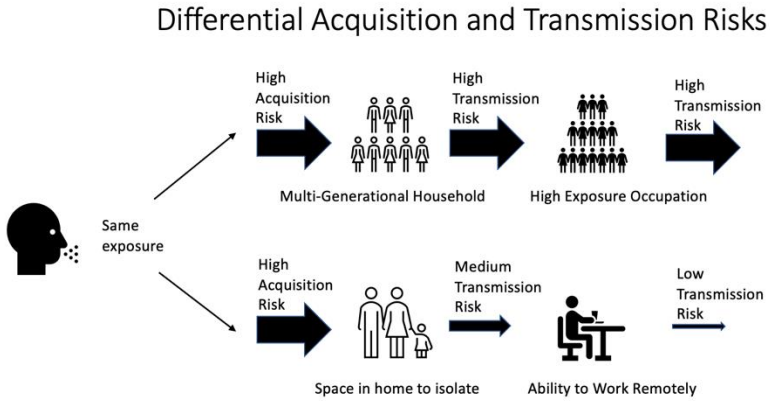
1. Definitions of occupations and workplace settings differ across studies, which can mean that sectors/occupational groups may not be directly compared in different studies and sector-wide comparisons may be inappropriate, because of the variety of activities within them. None of the occupational groupings commonly used were devised with respect to risk of exposure to respiratory infections.
2. Sampling bias influences the relative representation of occupations and incomplete sampling can lead to bias in studies. For example, PHE contact-tracing analysis is based on people who have come forward for testing, compared with 'general population' controls; this may create a bias if certain occupations are more likely to be tested and/or those identified as contacts. Similar challenges can apply to controls. Some of this can be offset with volume of testing.
3. Confounding variables and effect modifiers include – socioeconomic effects, deprivation, age, sex and ethnicity. Some of these are adjusted for in some studies, but it is very difficult to disentangle effects of occupation vs other factors which are associated with increased risk of transmission or mortality from COVID-19. For example, low paid workers are more likely to live in crowded and/or mostly multigenerational households where vulnerable or elderly members live. They are more likely to live in dense neighbourhoods, less likely to be tested and less able to self-isolate, use communal transport, all factors associated with increased transmission risk.[4] After adjustment, effect size in some cases changes or disappears. The interfaces between occupations and other settings, including transport, and how these may have changed over the past year, are not accounted for but are an important factor when considering risk of transmission.
4. Transmission can occur both within and between settings. It is dependent on duration and density of contacts, how people interact within each setting, number of 'at risk' contacts in each setting and the mitigation measures in place within them. Identifying the precise location and determinants of transmission is complex.
5. Variation in settings – HSE spot inspections (including both telephone and on-the-ground inspections) have shown greater than 90% compliance with the guidance on control measures. The features of those occupational and workplace settings that lead to increased risk is important to understand and requires detailed investigation through outbreak studies. The extent to which these mitigations reduce risk is not known.
6. Influence of restrictions on workplace settings and occupations. Some organisations have been subject to more severe restrictions than others, meaning that risk in some is not possible to estimate simply because they have been closed for long periods over the past year.
7. The datasets considered in this paper span a range of timepoints. Consequently, the nature and the extent of NPIs in place at the time of the study may affect the results.

The paper describes risks of transmission, and mortality, within occupational groups. It is important to note that this is not analogous to the contribution that the sector (within which such occupations exist) makes to transmission or mortality at population level. Those population effects are contingent upon multiple additional factors such as the number and range of contacts of people within an occupational group, the nature and breadth of the networks of those contacts, their vulnerability, and

so on. It is therefore important not to conflate within-occupation risks with the risks of population level transmission from people in any occupation; they may be equivalent, but they also may not.

Figure 1 illustrates simply how home environmental conditions and workplaces can together impact on the risk of transmission for an individual, and the potential for onward transmission.

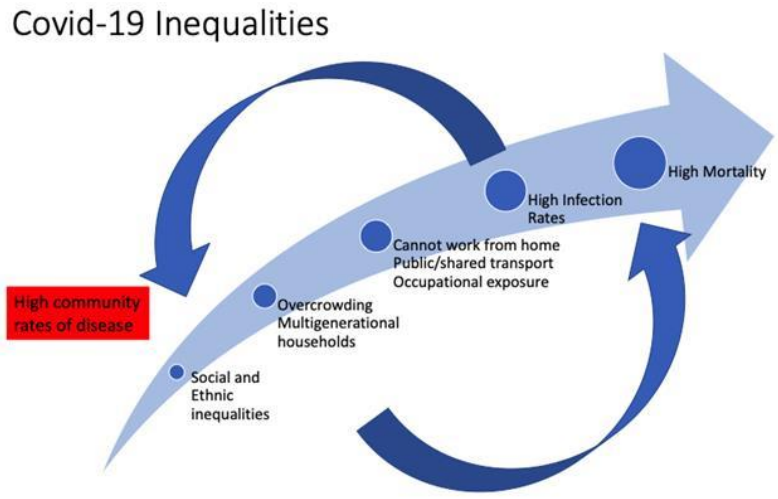
Figure 1. Differential Acquisition and Transmission Risks



It should also be clearly noted that ***occupational risks are interlinked with other factors such as household size, socioeconomic inequalities and financial barriers to isolation and inability to work from home, which affect individuals' risk of infection***.

Figure 2 shows that the raised risk of infection due to occupational exposure will also lead to increased transmissions in the homes and communities of people within these occupational groups, so it is often not possible to measure the relative contribution of the different environments as they are highly interlinked with bidirectional causal pathways. Given the strong connections between certain occupation and social circumstances and the dynamic processes involved, simply controlling for these variables within models may underplay occupational and other risks.

Figure 2. Linkages between raised risk of infection and social inequalities



4. Overview: Occupation and COVID-19 transmission.

A person's occupation may have an important impact on the likelihood that they will be exposed to the SARS-CoV-2 virus and become infected. Occupational risks are also reflected in variations in hospitalisation and mortality rates in different occupations (high confidence).

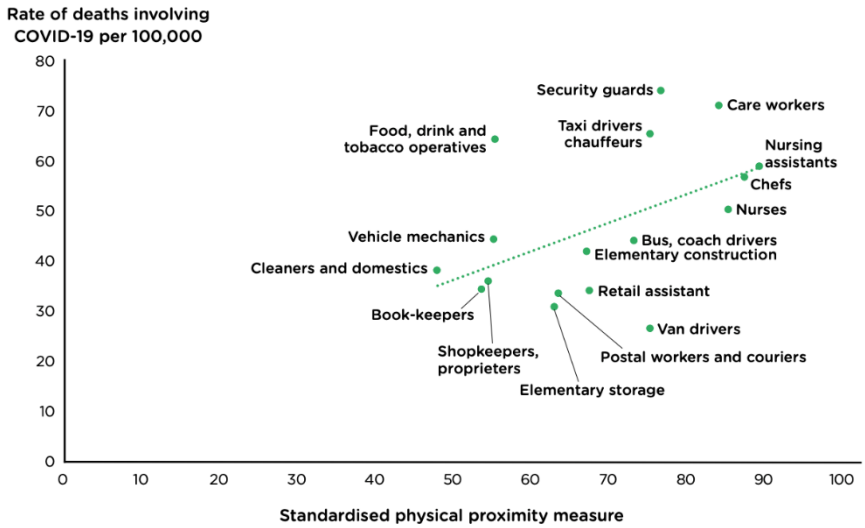
Different occupations have differing ability to work from home. Analysis of the labour force survey data from April 2020[5] (during the first lockdown) showed nearly half (46.6%) of people in employment did some of their work from home, with the vast majority (86.0%) of these homeworkers stating that this was because of the coronavirus (COVID-19) pandemic. People aged 16 to 24 years were less likely to do some work from home. Occupations requiring higher qualifications and more experience were more likely to provide homeworking opportunities than elementary and manual occupations. There were large differentials in the proportion working from home in different occupational categories.

The ability to work from home is usually not within the control of individuals and is more likely to be determined by the policies of their employer. Hence actions to encourage home working should encourage employers to enable their staff to work from home where possible.[6] In addition to reductions in risks of workplace transmission this will also reduce associated risks such as those from using public transport, and increase transport system capacity for those who have no choice but to travel. ONS data (27-31st January 2021) shows the number of people who report going to their workplace at least one day a week when they could work from home full time is 25%.[7]

Occupations that are less likely to be able to work from home have higher COVID-19 mortality rates than those that can work from home (high confidence). Those occupational categories with high rates of home working (Managers directors and senior officials, Professional occupations, associate professional and technical occupations) had markedly lower age standardised mortality rates than those occupations that rarely worked from home (process plant and machine operatives, sales and customer services occupations, caring leisure and other services occupations, skilled trade operations). Owing to small numbers, home working in elementary occupations was not reported. This group had the highest age standardised mortality rate and comprise low skilled manual labour occupations that are unlikely to be able to be conducted from home.[8]

Occupations which involve a higher degree of physical proximity to others tend to have higher COVID-19 mortality rates (high confidence). The relative risks will depend on the type of contact (colleagues/public), the frequency of contact, the duration of contact, and the likelihood that the contact is infected. The closeness of contact with others and prolonged contact in work settings varies considerably by occupation and there is evidence that occupations with higher levels of physical proximity to others have higher COVID-19 age standardised mortality rates.[9]

Figure 3. Age standardised male mortality rates (per 100,000) at ages 20 to 64 in 17 high risk occupations by proximity to others, based on deaths involving COVID-19 registered in England and Wales between 9 March 2020 and 25 May 2020[10]

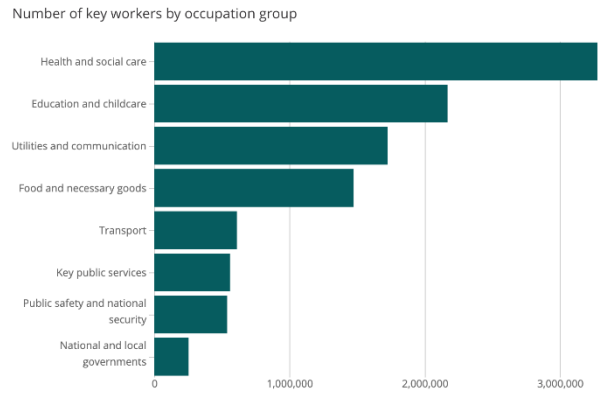


People working in patient-facing roles are much more likely than the comparison group to be the first case in their household. An as yet unpublished analysis using ONS COVID Infection Survey data shows that people working in patient-facing roles are much more likely than the comparison group to be the first case in their household (external exposure). However, the risk has changed over time, as the data in Table 2 illustrate. This variability corresponds to the variation in COVID-19 cases and hospital admissions over the time periods. The observed downward trend in risk to patient-facing workers as a function of numbers in hospital, could reflect a combination of better infection prevention and control over the second wave. This could also be influenced by vaccines and natural immunity among those who have previously had the virus.

Table 2. Risk of patient-facing workers relative to non-patient-facing workers

Time Period	Risk Estimate	Confidence intervals (95%)
Up to September 1st 2020	3.2 times the risk	2.1 to 4.9
September 1 to 15 November 2020	1.2 times the risk	1.0 to 1.4
15th November to 1st January 2021	1.5 times the risk	1.3 to 1.8
1st Jan to 1st February 2021	1.7 times the risk	1.4 to 1.9

Figure 4. Key workers in the UK[11]



Key workers mainly in health and social care are more likely to become infected with COVID-19 than non-key workers (high confidence). During the first national lockdown the government defined a group of workers whose job was considered essential to societal functioning as Key Workers – this comprised around one third of the total workforce (10.6 million people). The largest category was Health and Social Care. 15% of key workers had chronic health conditions placing them at "moderate risk" from COVID-19 infection. Those in BAME ethnic groups were more likely to be in key worker occupations, with a particular over-representation in Health and Social Care and these groups have in general been overrepresented in mortality. Previous analysis from ONS has shown that most minority ethnicities have a higher COVID-19 hospitalisation and mortality rate relative to the white population. The REACT 1 study has shown both healthcare and care home workers, and other key workers, had increased odds of swab-positivity during lockdown compared to other workers at 1.48 and 1.35 respectively.[12]

Summary of key analyses by occupation

PHE[13]:

- Occupational exposure risks: Analysis from four contact tracing case-control studies found that there was strong evidence that people working in healthcare, social care or hospitality were more likely to be COVID cases compared to other occupations.
- Workplace setting exposure risks: settings that were found to be associated with increased risk of acquiring COVID-19 compared to a control group were: working in healthcare, social care or hospitality, working in warehouse settings, and working in construction.
- Trends over time: Warehouse settings were the only sector not to see a decline in case rates after the November lockdown, and instead showed an increase over time. It is possible that this is due to increased retail activity over the festive season.
- Outbreaks: Reporting through the PHE outbreak surveillance system shows outbreaks can occur in all workplace settings. The most commonly reported settings included health and social care, construction sites, manufacturing, warehouses, transport and restaurants and pubs.

ONS:

- Occupational exposure risks: Process, plant and machine operative occupations had the highest rate of mortality from COVID-19. Caring, leisure and other service occupations - the

major group with the next highest rate of death involving COVID-19 - had the largest number of deaths of all the major groups.[14]

- In addition to health and social care occupations a range of other occupations had increased case fatality rates with the occupations most at risk varying by gender. Some of the occupations identified as at increased risk were also consistent with other analyses including:
    - For men - those working in manufacturing, chefs, those in public-facing transport roles (including bus and taxi drivers) and security guards; and
    - For women - those working in retail and caring or personal services. Further details are provided in section 5b.

Interim analysis from University of Liverpool using Covid Infection Survey data from September 2020 onwards:

- Occupational exposure risks: For women aged 20-40, certain sectors of employment represented increased risk of COVID-19, with an increased risk of COVID-19 among individuals employed in personal services (e.g. hairdressers), health care, education and social care. For personal services, there appears to be an increase in tests positive from September 2020, with other sectors' tests positive increasing later in October and November 2020.

HSE Guidance and Compliance:

- The majority of businesses with which HSE has had contact have been able to provide assurance that they have complied with relevant guidance to introduce controls to reduce the risk of workplace transmission of COVID-19.
- Among 92,000 businesses contacted by HSE, only around 1,500 (under 2%) were found to be in breach of the regulations that require them to protect their workers from health risks and only 195 have required a formal enforcement notice in order to secure compliance.
- Although it is reassuring that businesses are reporting action to reduce COVID-19 transmission, the effectiveness of COVID-19 control measures in the workplace is unknown and the variation in the occupational mortality rates suggests that regardless of the controls that employers are putting in place, some groups of workers remain at higher risk.

5. Underpinning data and context

a. International data

Data consistently describe higher risks of exposure for those working in public facing jobs, those not amenable to remote work, often those roles associated with lower income. While the majority of prevention strategies have focused on health care institutions and long-term care facilities, other multioccupancy living settings such as homeless shelters, prisons, and migrant work camps have also been associated with large scale outbreaks amongst residents and staff.[15] In addition, there have been significant risks associated with other workplaces. In Ontario, Canada, 80% of workplace associated outbreaks were in three industry sectors: Manufacturing, Agriculture and Transportation, Warehousing.[16] In the same analysis, associated household transmission occurred among 31% of outbreak cases, and accounting for household cases among cases with a valid address increased the burden of illness associated with workplace outbreaks by 56%.

In Sweden[17], the relative risk of being diagnosed with COVID-19 differs between different occupational groups (care workers, police officers and security guards, service sector personnel, delivery workers, taxi- and bus drivers, teachers, meat packers, and cleaners). The highest relative prevalence was found among taxi drivers followed by some specific groups including bus and tram drivers, pizza bakers and

delivery persons. Another Swedish study found that taxi and bus drivers had a substantially higher COVID-19 infection and mortality risk than other workers, though this difference was diminished when adjusted for other characteristics.[18] A US study[19] assessed excess mortality (comparing with mortality rates pre-pandemic) in different essential and non-essential worker categories. Compared to non-essential workers the following essential worker groups had significantly increased excess mortality: those working in food and agriculture, transportation or logistics, facilities, manufacturing, health and emergency services and retail. For most occupational categories the risk ratios for mortality comparing pandemic to non-pandemic time were higher in non-white ethnic groups (Table 3, Table 4).

Table 3. Risk ratios for mortality, comparing pandemic time to non-pandemic time, among California residents 18-65 years of age, by occupational sector and race/ethnicity, March through October 2020[20]

	All races	Asian	Black	Latino	White
All sectors	1.22 (1.20–1.24)	1.18 (1.14–1.23)	1.28 (1.24–1.33)	1.36 (1.29–1.44)	1.06 (1.02–1.12)
Food or agriculture	1.39 (1.32–1.48)	1.18 (1.05–1.33)	1.34 (1.19–1.54)	1.59 (1.47–1.75)	1.16 (1.09–1.24)
Transportation or logistics	1.28 (1.24–1.33)	1.26 (1.12–1.44)	1.35 (1.26–1.46)	1.40 (1.31–1.52)	1.10 (1.02–1.20)
Facilities	1.27 (1.22–1.32)	1.24 (1.08–1.46)	1.25 (1.17–1.34)	1.38 (1.27–1.51)	1.11 (1.04–1.20)
Unemployed or missing	1.23 (1.19–1.27)	1.08 (1.04–1.14)	1.31 (1.22–1.40)	1.31 (1.22–1.41)	1.09 (1.01–1.20)
Manufacturing	1.23 (1.18–1.28)	1.18 (1.06–1.33)	1.13 (1.01–1.30)	1.44 (1.34–1.57)	1.00 (0.92–1.10)
Health or emergency	1.19 (1.17–1.22)	1.40 (1.33–1.49)	1.27 (1.17–1.40)	1.32 (1.18–1.51)	1.02 (0.96–1.10)
Retail	1.18 (1.14–1.23)	1.10 (1.00–1.22)	1.36 (1.21–1.55)	1.40 (1.28–1.55)	1.08 (1.04–1.13)
Government or community	1.14 (1.11–1.18)	1.22 (1.07–1.41)	1.20 (1.09–1.33)	1.42 (1.32–1.53)	0.96 (0.89–1.04)
Not essential	1.11 (1.08–1.14)	1.14 (1.06–1.23)	1.23 (1.15–1.33)	1.29 (1.20–1.41)	1.00 (0.95–1.07)

Specific occupations with increased excess mortality are shown below.

Table 4. Risk ratios for mortality, comparing pandemic time to non-pandemic time, among California residents 18-65 years of age, by occupation, March through October 2020[21]

Code	Description	Deaths[a]	Risk ratio
4020	Cooks	828	1.60
8800	Packaging and filling machine operators and tenders	172	1.59
6050	Miscellaneous agricultural workers	617	1.55
7800	Bakers	104	1.50
6260	Construction laborers	1,587	1.49
8965	Production workers, all other	452	1.46
8320	Sewing machine operators	127	1.44
5610	Shipping, receiving, and traffic clerks	146	1.44
4250	Grounds maintenance workers	712	1.40
5240	Customer service representatives	562	1.37
4000	Chefs and head cooks	532	1.35
1107	Computer occupations, all other	136	1.35
9600	Industrial truck and tractor operators	364	1.34
3500	Licensed practical and licensed vocational nurses	109	1.34
0410	Property, real estate, and community association managers	157	1.33
4230	Maids and housekeeping cleaners	378	1.33
3930	Security guards and gaming surveillance officers	707	1.32
9130	Driver/sales workers and truck drivers	1,962	1.32
9830	Military, rank not specified	111	1.32
9620	Laborers and freight, stock, and material movers, hand	2,550	1.31
5940	Office and administrative support workers, all other	123	1.30
7750	Miscellaneous assemblers and fabricators	354	1.29
2010	Social workers	217	1.28
4040	Bartenders	148	1.28
2540	Teacher assistants	183	1.28

[a] Number of deaths in pandemic time. The table is restricted to occupations with 100 or more pandemic-time deaths.

b. Intersection between occupational risk, housing and socioeconomic inequalities

International studies show there has been a clear intersection of COVID-19 transmission networks and socioeconomic inequities, reflecting the amplifying effects of working in public facing jobs, crowded housing, job insecurity, and poverty.

Social determinants related to housing, education, and recent immigration were associated with increased COVID-19 risks, with little evidence of selection bias. In the US, the COVID-19 pandemic disproportionately impacted the Latino population, a segment of the workforce that experiences ongoing occupational exposure. In addition to meatpacking plants, a large proportion of this community is employed in factories or in other service-based industries.[22]

There is now international consensus that those living in households with more people living in them have a higher risk of being affected by COVID-19. In a large observational study[23] of 14.7 million Canadians, household density was strongly associated with increased risk of infection. In England, those living in the most deprived neighbourhoods, and largest households, had higher odds of swab-positivity.[24] These analyses indicate that large households act as amplifiers of transmission.

In addition, inequities further concentrate risk via connections between networks. The highest COVID-19 mortality has been observed in facility-based outbreaks, including in long term care facilities, retirement homes, and homeless shelters. Staff in long term care and similar occupations are low paid, often on zero hours contracts and long-term care staff diagnosed with COVID-19 were disproportionately more likely to reside in hardest-hit neighbourhoods which are also most deprived neighbourhoods.[25]

The ability to quarantine until test results are available, and to isolate if positive, depends on people having the space and resources to do so. Survey data from the UK suggest that less than one in five people are able to adhere to isolation protocols.[26,27] Notably, lower rates of adherence have been reported among men, younger people, key workers, those living with dependent children, and those in lower socioeconomic groups. Although willingness to self-isolate was high across all respondents, the self-reported ability to isolate was three times lower among those earning less than £20 000 a year or who had less than £100 saved.[28] This finding is consistent with reports that lost wages are the primary reason for not following isolation guidelines.

Therefore, these occupational factors are closely related to socioeconomic inequalities and underlying vulnerabilities including higher exposure due to working hours, working in precarious and low-paid or multiple jobs, and increased risk due to living conditions, and ability to self-isolate.

c. Analysis of England and Wales Mortality rates

A recent analysis[29] compared age standardised COVID-19 mortality rates by occupational group in working age men and women (March-December 2020) in England and Wales.

i) Men

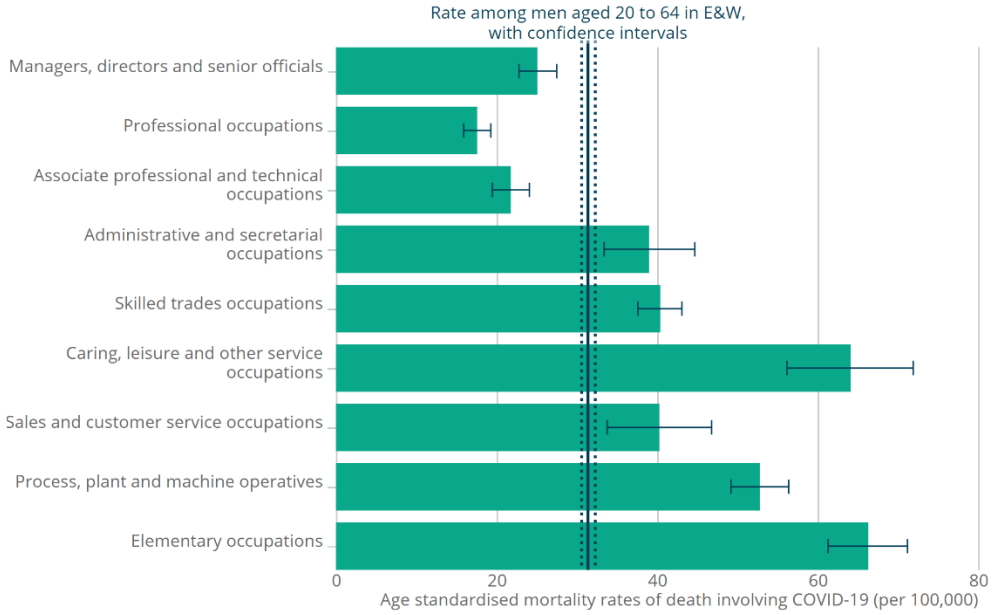
When looking at broad groups of occupations, men who worked in elementary occupations or caring, leisure and other service occupations had the highest rates of death involving COVID-19.

Occupations classified as elementary occupations are those which will usually require a minimum general level of education (i.e. that which is acquired by the end of the period of compulsory education). Some occupations at this level will also have short periods of work-related training in areas such as health and safety, food hygiene, and customer service requirements.

Six of the nine major occupational groups had statistically significantly higher rates of death involving the coronavirus (COVID-19) when compared with the rate of COVID-19 among men of the same age in the population. These included (from the highest to the lowest rate):

- elementary occupations (66.3 deaths per 100,000 males; 699 deaths)
- caring, leisure and other service occupations (64.1 deaths per 100,000 males; 258 deaths)
- process, plant and machine operatives (52.8 deaths per 100,000 males; 827 deaths)
- skilled trades occupations (40.4 deaths per 100,000 males; 848 deaths)
- sales and customer service occupations (40.3 deaths per 100,000 males; 156 deaths)
- administrative and secretarial occupations (39.0 deaths per 100,000 males; 186 deaths)

Figure 5. Age standardised mortality rate per 100,000 men aged 20-64, 9 March 2020 to 28 December 2020, England and Wales



ii) Women

A summary of ONS data on number of deaths and age-standardised mortality rates involving the coronavirus (COVID-19) by occupational groups, in 20-64 year olds for deaths registered between 9 March and 28 December 2020 in England and Wales found that process, plant and machine operative occupations had the highest rate of death involving COVID-19. Of this major group, assemblers and routine operatives had the highest rate, with 39.2 deaths per 100,000 females (21 deaths), including jobs such as sewing machinists. However, because of the small numbers of deaths, it is not possible to reliably look at specific subgroup occupations among assemblers and routine operatives.

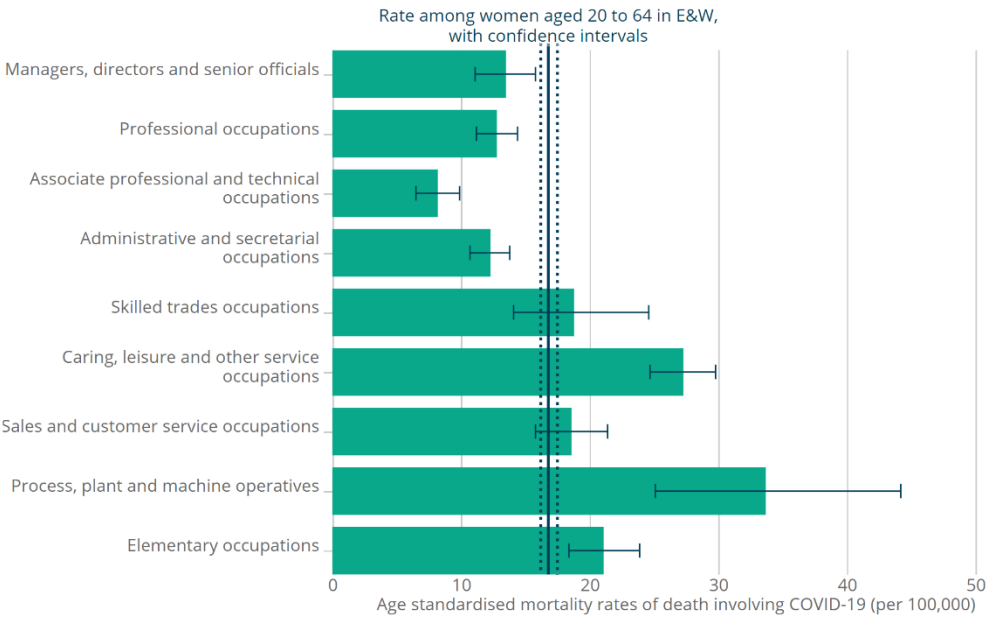
The group with the next highest death rate with COVID-19 listed on death certificate was caring, leisure and other service occupations. This group had the largest number of deaths of all the major groups (460 out of 1,742 deaths; 26.4%). Most of the deaths in this group were among those who worked in caring and personal services (326 deaths; 38.3 deaths per 100,000 females). Of the caring personal services occupations, care workers and home carers had the highest rate of death involving COVID-19 (47.1 deaths per 100,000 females; 240 deaths).

Outside of these groups, occupations with the highest rates of death involving COVID-19 included:

- social workers (32.4 deaths per 100,000 females; 25 deaths)

- national government administrative occupations (27.9 deaths per 100,000 females; 26 deaths)
- sales and retail assistants (26.9 deaths per 100,000 females; 111 deaths)
- managers and directors in retail and wholesale (26.7 deaths per 100,000 females, 24 deaths)
- nursing auxiliaries and assistants (25.3 deaths per 100,000 females; 54 deaths)
- nurses (24.5 deaths per 100,000 females; 110 deaths)

Figure 6. Age standardised mortality rate per 100,000 women aged 20-64, 9 March 2020 to 28 December 2020, England and Wales



About the analysis:

Occupation is reported on the death certificate at the time of death registration by the informant. This information was then coded using the Standard Occupational Classification 2010 (SOC 2010).

During the period of the analysis, a total of 5,128 deaths and 2,833 deaths involving COVID-19 were registered among men and women aged 20 to 64 years, respectively. In men, 82.4% of these deaths (4,225) had information recorded on occupation; for women this figure was 61.5% (1,742 deaths). Of the records included in the analysis of COVID-19 deaths by occupation, the mean age at death for both men and women was age 56 years. These statistics include deaths where COVID-19 was mentioned on the death certificate as a contributing factor, but not necessarily as the cause of death.

Caveats:

Analysis was adjusted for age and sex but not for other factors such as ethnic group, place of residence or deprivation. However, given the collinearity between occupation and social circumstances it may be difficult to separate the effects of workplace exposures and social circumstances, and a large part of the increased risk in socially deprived areas may relate to occupation and could be further amplified by other factors such as use of public or shared transport, overcrowding, and a susceptibility to underlying health conditions. Nevertheless, it is important that such adjustments are done, and the adjusted and unadjusted results are compared, as this would aid the interpretation of the findings.

iii) Effect of lockdown on mortality rates by occupation

For both sexes, age-standardised rates of death involving COVID-19 by occupation were statistically significantly lower during first lockdown than before lockdown.[30]

Across the entire time period, some groups of occupations, which largely remained open, continued to have high rates of death involving COVID-19, when compared with rates among those of the same age and sex in the population.

Among men, four of the nine major occupation groups (elementary; caring, leisure and personal services; process, plant and machine operatives; and skilled trades) had statistically significantly higher rates of death involving COVID-19 both before and during lockdown, when compared with rates among those of same age and sex in the population.

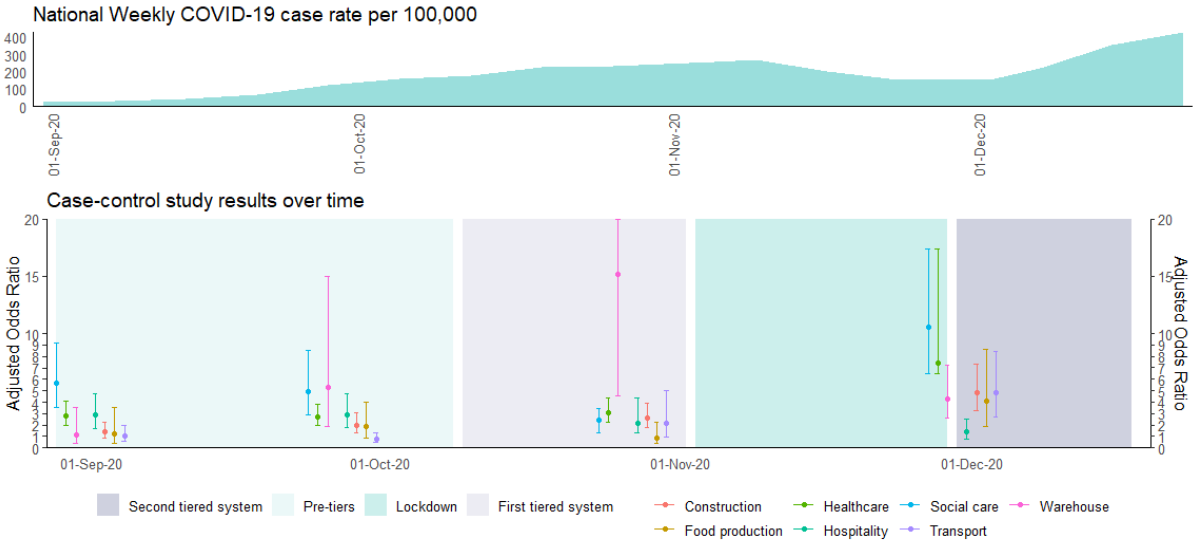
Caring, leisure and other services was the only major occupation group to have a statistically significantly higher rate of death involving COVID-19 among women both before and during lockdown, when compared with rates among those of the same age and sex in the population.

Among health and social care professionals, rates of death involving COVID-19 in men were around three times higher when the virus was more likely acquired before lockdown than during lockdown; in women, rates were around two times higher.

d. Case Control Studies

Four case control studies have been conducted by PHE at approximately monthly intervals (end of August, end of September, end of October and end of November / early December). Figure 7 shows the study results in the context of national restrictions and the national infection rates. A key strength of these studies is the ability to control for multiple confounding variables, increasing the confidence that the occupational exposures rather than associated living conditions are the cause of the association.

Figure 7. PHE case-control study results over time



Summary

The odds of infection varied over time as a result of NPIs and local and national lockdowns. The four case-control studies conducted found strong evidence that working in healthcare (aORs 2.81, 2.72, 3.08, 7.41 for studies 1-4 respectively), social care (aORs 5.41, 5.06, 2.46, 10.6 for studies 1-4 respectively) or hospitality (aORs 2.53, 2.63, 2.01 for studies 1-3 respectively) was associated with testing positive for COVID-19. The 4th study period took place during the time of national lockdown (Figure 7), when especially hospitality venues were closed. There was a substantial decrease in the aORs for the association between working in hospitality and becoming a COVID-19 case in the 4th study period compared to the aORs measured in previous study periods, while for most of the other sectors the observed associations were much stronger in the 4th study compared to previous study periods.

Warehouse settings were associated with increased odds (aORs 1.06, 3.93, 14.19, 4.30 for studies 1-4 respectively), with a substantial increase in odds observed over the study periods. A similar case control study in France[31] had consistent findings and also found factory workers (adjusted odds ratio 1.37, 1.00-1.91) and drivers (adjusted odds ratio 2.51, 1.57-3.97) to be at significantly increased risk of COVID-19 infection.

Case-control study data methodology and analysis

The data for the cases was collected through NHS T&T, where cases provided the information either through a digital route (self-completed) or through being interviewed over the phone. Information was collected on workplace, education and leisure activities in the 2-7 day period before symptom onset (or date of test if onset date was not provided). Controls who were recruited concurrently, completed an online survey with same activity questions Controls were frequency matched by 3 age groups (18-29 years, 30-49, 50 and above) and by geography (London, South England, North England, Midlands) to take into account the distribution of the infection and the regional implementation of NPIs. Crude odds ratios (cORs) were obtained for each main exposure. Adjusted odds ratios (aORs) were obtained through multivariable analyses using penalised regression methods (see Firth, 1993). All multivariable analyses were adjusted for age, sex, ethnicity, socioeconomic deprivation (using index for multiple deprivation (IMD)), geographical region, and non-work community and leisure activities.

Limitations

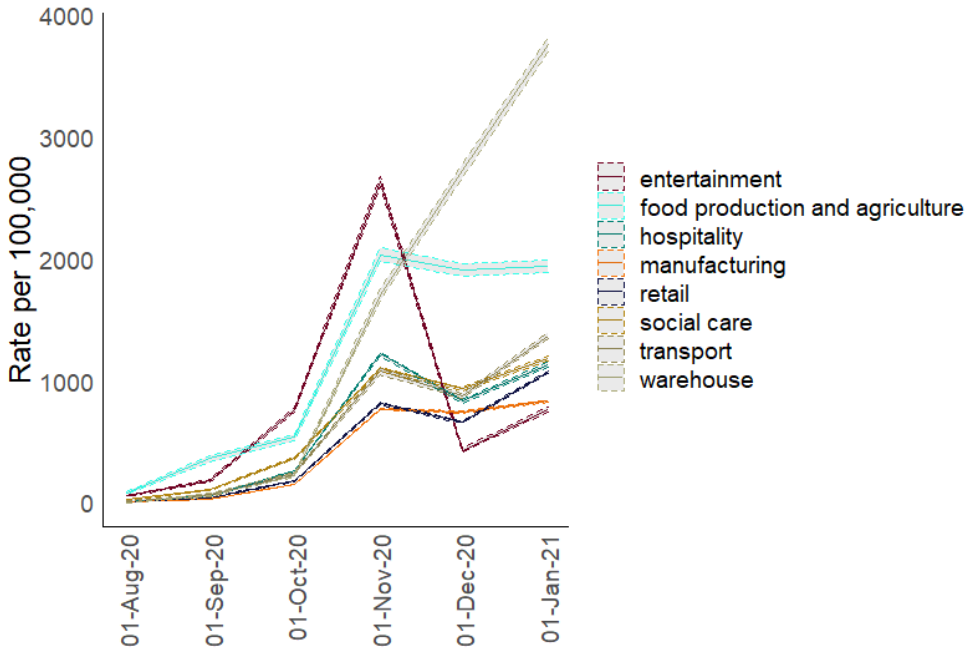
It is not possible to determine how much of the transmission of SARS-CoV-2 took place within the workplace, and how much was associated with social, household or transport exposures not captured by the study. The study may be subject to selection bias as only cases who were tested are included and the controls were recruited from Market Research Panels and therefore may not represent accurately the general population of England. There is also differential misclassification of exposure. It is for example plausible that cases are under-reporting their activities potentially due to issues with questionnaire fatigue or being more likely to adhere to socially desirable reporting. Controls are less likely to be affected by questionnaire fatigue and were paid to complete the survey. However, it is difficult to determine whether the biases causing the misclassification led to under- or overestimation of specific effect measures. While multivariable models were adjusted for confounding of all the available demographic variables, some residual confounding is likely to persist.

e. COVID-19 case rates by occupational sectors

Using workplace data reported by cases in the routine NHS T&T data and taking the denominators from ONS data, occupational case rates were calculated. The denominators used in this analysis were fixed and not adjusted for any changes that may have occurred over time in the number of people

working in these sectors. Warehouse settings were also the only sector not to see a decline in case rates after the November lockdown, and instead showed an increase over time (Figure 8).

Figure 8. Monthly COVID-19 case rate per 100,000 by occupational sector (NHS T&T, ONS)



f. Secondary attack rates

The overall secondary attack rate, calculated among named close contacts of people with COVID-19 in NHS Test and Trace from 01 August to 31 December 2020, was 9.4%. Although highest among household contacts (10.3%), transmission events to contacts within workplace settings was also observed representing 4.2% of named contacts. There was no marked variation in secondary attack rates in close contacts in different workplace settings, which is expected given that definitions of close contact are the same across settings. It was notable that close contact services (such as hairdressing) had lower secondary attack rates; this may relate to more rigorous use of personal protective equipment by staff as well as mandatory face coverings for customers in this sector. Secondary attack rates should be considered minimum estimates due to the method of ascertainment (see methods).

Table 5. Secondary attack rates among named close contacts by selected workplace settings, 24 October to 31 December 2020[32]

	Work category	**Contacts who became cases**	Total number of close contacts	
		n	**N**	**%**
Workplace	Military (incl. civilian employees)	59	949	**6.2**
	Information and communication	143	2,336	**6.1**
	Financial services incl. insurance	178	3,069	**5.8**
	Arts, entertainment or recreation	123	2,161	**5.7**
	Emergency services	217	3,815	**5.7**

	Social care or home care	326	6,091	**5.4**
	Manufacturing or construction	941	18,370	**5.1**
	Civil service or Local Government	223	4,436	**5.0**
	Food production and agriculture	133	2,679	**5.0**
	Transport	259	5,308	**4.9**
	Other occupational sector	1,181	24,918	**4.7**
	Warehouse or distribution	221	4,769	**4.6**
	Hospitality	455	10,121	**4.5**
	Health care	640	14,313	**4.5**
	Work travel or activity outside workplace	34	852	**4.0**
	Retail sector	669	17,021	**3.9**
	Critical national infrastructure	36	960	**3.8**
	Prison / detention facility	34	985	**3.5**
	Immigration / border force services	3	88	**3.4**
	Close contact services	146	5,004	**2.9**

Secondary attack rates data source and methods (PHE) [33]

Contacts with exposure dates within 01 August 2020 to 31 December 2020 were included in secondary attack rate analyses. Analyses for workplace settings were restricted to 24 October 2020 to 31 December 2020 due to a change in setting categories on 23 October 2020. CTAS data contains information collected from individuals with a positive test for SARS-CoV-2 referred to NHS Test and Trace ('cases') and individuals named by them as having been in contact with them between 2 days prior to symptom onset or test date and the date of tracing ('contacts').

Persons can arise multiple times as cases and/or contacts in the data and are matched with themselves via combination of name, NHS number, date of birth, address and contact information. Transmission is defined as a confirmed case (B) previously reported as a contact by a case (A), where the date for case (A) interacting with case (B) is between 2 and 14 days inclusive prior to the onset of symptoms (or test date) for case (B). Where there was more than one contact event within the transmission window leading to a case, one event is counted per case who was previously a contact, with priority given to household contacts and to later interactions.

As links are only identified between named people, and rely on contacts becoming symptomatic and accessing testing, secondary attack rates calculated here should be considered a minimum estimate.

Caveats

Ascertainment of cases and contacts by the National Test and Trace system may not provide a representative population of COVID-19 prevalence in the UK. Common reasons for this may include:

- Variation in testing procedures for different segments of the population, for instance students, health workers and asymptomatic cases, or by region.

- Not all contacts can be captured by contact tracing, for instance the case may not name some due to recall bias or stigma, and interpretations/definitions of contacts can vary by individual workplace, particularly in healthcare, hospitality or educational settings.
- The choice to prioritise household contacts may not be appropriate in all settings, for instance halls of residence may be classed as a single household and generate a large number of household contacts.

Data on risks in specific exposure settings can only be captured when those activities occur, and so is limited by regional restrictions and lockdowns. Such restrictions can also mean that activity events expose one to different risks in different regions, depending on activities permitted at any given time.

g. Outbreak data

Outbreaks of acute respiratory infections within workplace settings continue to be reported to Public Health England through this period, including during lockdown periods. Numbers of outbreaks should be interpreted with caution, due to how information can be reported to PHE, but reflect ongoing risk in a number of settings. Other outbreaks have been reported to these settings but without reported transmission among staff.

Table 6. Acute Respiratory infection situations in selected workplace settings by type of setting (16/08/20 – 31/01/21)

	August	September	October	November	December	January	Total
Manufacturers and packers Non Food	19	108	194	163	73	129	**686**
Office	13	128	207	115	82	117	**662**
Retailer	21	124	132	58	87	99	**521**
Distributors and Transporters	9	55	105	67	65	91	**392**
Manufacturers and packers Food	16	54	77	59	53	64	**323**
Restaurant and Caterers	4	32	38	17	7	6	**104**
Warehouses	7	17	28	8	19	15	**94**
Military sites	1	6	15	6	3	6	**37**
Close Contact Services	1	9	8	2	6	1	**27**
Other	27	154	262	268	208	306	**1225**

h. Interim analysis by University of Liverpool investigating occupational inequalities in COVID-19 for women aged 20-40

An analysis into occupational inequalities in COVID-19 focused on women aged 20-40 using data from the ONS COVID Infection Survey (CIS) found an increased risk was observed for women aged 20-40 who were parents with children aged 5 and over in full time education, with an increasing trend observed from September and peaking in October.

The analysis found increased risk of COVID-19 for women aged 20-40 by sector of employment, with increased risk of COVID-19 among individuals employed in personal services (such as hairdressing), health care and social care. For personal services, there appears to be an increase in September, with other sectors becoming more prevalent later in October and November.

Figure 9. Percentage of tests positives for males and females across Sectors

Figure 10. Percentage of positive tests for males and females across Sectors

For most sectors, the analysis saw increasing trends from August onwards, with a higher impact in the 'personal services' group among women in September (based on 2257 women). This appears to

precede the increases among the other groups. Other trends observed through focusing on the sectors with the highest prevalence by November see an increase in men aged 20-40 working teaching and education, transport, social care, hospitality and personal services (with a later peak than compared to females). For females aged 20-40, it is health care, social care, hospitality and the retail sector.

This work was conducted independent of ONS methodology and analysis teams. This work was produced using statistical data from ONS. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data.

i. HSE Context on Guidance and Compliance

HSE has published guidance for businesses on its webpages, describing how to make their workplace COVID secure. This has changed slightly over the course of the pandemic to reflect changes in the policy recommendations at the time (e.g. around use of face coverings, more recent advice to strengthen ventilation as a control). There have been 9.7 million views recorded for these pages, demonstrating a strong level of intent amongst businesses to understand what they need to do to make their workplaces secure.

Since June 2020, HSE has been conducting a spot check exercise and has completed telephone interviews with 92,000 businesses, in order to help provide assurance to businesses, regulatory bodies and the general public that employers are following government guidelines and keeping their workers safe. The interviews require employers to demonstrate their knowledge and understanding of COVID guidance and describe the measures they have put in place including risk assessments, social distancing arrangements, cleaning procedures and hand-washing facilities. In 93% of cases, businesses have been able to provide satisfactory assurance that they have appropriate controls in place.

Where HSE could not be fully confident about controls from the telephone interview, an inspector is assigned to follow up (usually with a site visit) and help the business achieve full compliance with the guidance. HSE also investigates concerns raised by workers and reports of COVID-19 cases made through the RIDDOR notification system, and has supported other regulatory bodies in the delivery of investigations of workplace outbreaks of COVID-19.

55% of businesses for which an intervention outcome has been recorded were able to demonstrate adequate controls and required no action to be taken by HSE. A further 36% of businesses have only required verbal advice in order to achieve compliance. Around 1,500 businesses have been sent a letter legally requiring them to make improvements in order to better protect their workers. This represents just under 10% of those businesses who have been the subject of an inspection or investigation, and around 1% of the total number of businesses HSE has contacted. Formal enforcement notices have been served in 195 cases.

Where inspectors have taken any enforcement action (whether that be verbal advice, written advice or a formal enforcement notice), they have recorded the single issue which was most relevant to their enforcement decision. The most common issue was social distancing, cited in just under 50% of cases, followed by cleaning regimes (just over 20% of cases) and management arrangements (around 15% of cases).

Findings have been similar in the local authority enforced sector. Of the 10,500 spot checks in this sector, 91% of businesses were able to demonstrate compliance. 900 businesses which were not able to provide sufficient assurance have been visited by local authorities, with 200 of these requiring verbal advice, a further 100 sent a letter requiring improvements to be made and 13 served with formal enforcement notices.

Table 7. Risk Factors with respect to place and transmission (SAGE-EMG)

The following table was presented in previous EMG/Nervtag/Transmission group papers and summarises key risk factors

Factors associated with risk of transmission	Lowest risk of transmission	Highest risk of transmission
Environmental factors		
Proximity	Always maintain >2m	Regular close interaction < 1m
Duration	A few minutes or less	Several hours
Occupant density	People spaced out, large space	People closely packed, small space
Shared air	Outdoors, well ventilated indoor	Indoors with poor ventilation, recirculated air
Environmental conditions	Normal indoor temperatures, humidity and fresh air	Low temperature, low humidity
Viral emission	Passive activity, face coverings	Aerobic activity, singing, loud talking, no face Coverings
Shared surfaces	Rarely touch shared surfaces, good cleaning	Regular touching shared surfaces, infrequent cleaning
Human factors		
Contact frequency	Case isolation, infrequent contact	Daily, regular contact
Networked	Contacts maintained within a small bubble	Shared space with multiple strangers
Hygiene behaviours	Regular hand hygiene, use of face coverings	Poor hand hygiene, no face coverings
Occupational factors	Small network, not public facing	Care/health sector, public facing, long working hours
Socio-economic factors	Work from home, able to isolate	Poverty, crowded housing, inability to isolate for both space and financial reasons

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