Annals of Work Exposures and Health, 2023, Vol. 67, No. 1, 147–152
https://doi.org/10.1093/annweh/wxac042
Advance Access publication 15 June 2022
Short Communication

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An Ecological Study of COVID-19 Infection Rates within the UK Food and Drink Processing Industry

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Submitted 11 January 2022; revised 29 April 2022; editorial decision 20 May 2022; revised version accepted 3 June 2022.

Abstract

Objectives: Food processing facilities represent critical infrastructure that have stayed open during much of the COVID-19 pandemic. Understanding the burden of COVID-19 in this sector is thus important to help reduce the potential for workplace infection in future outbreaks.
Methods: We undertook a workplace survey in the UK food and drink processing sector and collected information on workplace size, characteristics (e.g. temperature, ventilation), and experience with COVID-19 (e.g. numbers of positive cases). For each site, we calculated COVID-19 case rates per month per 1000 workers. We performed an ecological analysis using negative binomial regression to assess the association between COVID-19 rates and workplace and local risk factors.
Results: Respondents from 33 companies including 66 individual sites completed the survey. COVID-19 cases were reported from the start of the pandemic up to June 2021. Respondents represented a range of industry subgroups, including grain milling/storage ($n = 16$), manufacture of malt ($n = 14$), manufacture of prepared meals ($n = 12$), manufacture of beverages ($n = 8$), distilling ($n = 5$), manufacture of baked goods ($n = 5$), and other ($n = 6$), with a total of 15 563 workers across all sites. Average monthly case rates per 1000 workers ranged from 0.9 in distilling to 6.1 in grain milling/storage. Incidence rate ratios were partially attenuated after adjusting for several local and workplace factors, though risks for one subgroup (grain milling/storage) remained elevated. Certain local and workplace characteristics were related to higher infection rates, such as higher deprivation (5 km only), a lower proportion of remote workers, lower proportion of workers in close proximity, and higher numbers of workers overall.
Conclusions: Our analysis suggests some heterogeneity in the rates of COVID-19 across sectors of the UK food and drink processing industry. Infection rates were associated with deprivation, the proportions of remote workers and workers in close proximity, and the number of workers.

Keywords: COVID-19; infection control; occupational health; pandemic; workplace transmission

What's important about this paper

Food processing facilities represent critical infrastructure that have stayed open during much of the COVID-19 pandemic. This study surveyed 66 sites in the UK food and drink processing industry and found heterogeneity in COVID-19 rates across industry sectors, even after adjusting for workplace and local factors. Understanding the burden of COVID-19 in this sector is thus important to help reduce the potential for workplace infection in future outbreaks.

Introduction

Food processing facilities represent critical infrastructure that have stayed open during much of the COVID-19 pandemic. Work-related transmission risks of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19, were highlighted early in the pandemic, especially in meat and poultry processing plants (Dyal, 2020; Hailu, 2021; Pokora *et al.*, 2021). Conditions that can enhance virus transmission, such as high-density work areas, prolonged close contact with others, shared transport and housing, and community contact among co-workers, have been highlighted in food processing facilities (Waltenburg *et al.*, 2021).

Analysis of COVID-19 outbreaks by sector across England during May–October 2020, found the highest rates for food manufacturing and packing (Chen *et al.*, 2021). Similarly, a study of workplace outbreaks in Los Angeles County, USA identified the most outbreak-associated cases among industry subsectors to be in 'food manufacturing' (Contreras *et al.*, 2021). A review of SARS-CoV-2 transmission in the food processing sector suggested increased risks in workplaces with colder and more humid environments, lack of social distancing, and poor ventilation. Various risk mitigation strategies for the sector have been offered, including social distancing, cleaning and disinfecting high-touch areas, enhancement of ventilation, and providing more community and work-based testing (P. Hosseini *et al.*, unpublished data). The effectiveness of these measures may be strengthened by supportive workplace policies, such as educating workers about hygiene measures and offering sick pay (Bui *et al.*, 2020; Herstein *et al.*, 2021).

As part of the multistage Covid at Work Study (CaWS), we developed a workplace survey in the UK food and drink processing sector to obtain information on the rates experienced across different types of facilities in the sector and to assess the association with risk factors and mitigation measures. This survey represents stage 1, which will inform in-depth structured interviews involving a subset of these same sites (stage 2), as well as supplemented by additional 'deep dive' interviews of experts and stakeholders across the sector (stage 3). CaWS is part of a National Core Study programme: Partnership for Research in Occupational, Transport, Environmental COVID Transmission (PROTECT).

Methods

We developed an online survey to ascertain site-specific information on workplace factors (e.g. site purpose, number of workers), characteristics potentially related to transmission (e.g. ventilation, temperature), and COVID-19 outcomes (e.g. positive cases, testing) (see Supplementary Material, available at *Annals of Work Exposures and Health* online for full survey). The survey content was informed by a concurrent review we undertook on the food production sector (P. Hosseini *et al.*, unpublished data), and initial responses were reviewed to check if any revisions or clarifications were needed. To recruit companies, we held discussions with food federations and associations relevant for the UK food and drink processing sector. We encouraged them to send their members information about the survey, including the survey website.

The survey was administered via onlinesurveys.ac.uk from 15 January to 15 July 2021. The study was approved by The London School of Hygiene and Tropical Medicine Research Ethics Committee (ref: 22908).

Local characteristics

Cumulative COVID-19 case rates per 100 000 population for lower tier local authorities (LTLAs) were obtained from the UK government (coronavirus.data.gov.uk/details/download). Site postcodes were matched to LTLAs. Cumulative cases were ascertained for the three time periods of the study, which approximated the first [March–June 2020 (T1)] and second [July–December 2020 (T2)] waves in the UK, as well as the varying survey submission period [January until the date of submission in 2021 (T3)]. These data were used to derive monthly 'background' rates overall and for each time period. As an indicator of area-level socioeconomic status (SES), the mean Index of Multiple Deprivation (IMD) decile in 1 and 5 km areas surrounding each facility were calculated separately for sites in England

and Scotland using data [based on Lower Layer Super Output Area (LSOA) for England and data zone for Scotland] for the years 2019 and 2020, respectively. The IMD is scored out of 10 and represents such neighbourhood-level features as housing, education, and health; higher scores represent lower levels of deprivation (i.e. higher SES).

Statistical analysis

We performed an ecological analysis of monthly COVID-19 incidence rates per 1000 employees at each site. The numerator was positive cases reported in a given time period and the denominator was total workers at the site; the ratio was then divided by the number of months in the period and multiplied by 1000. For T3, the number of COVID-19 cases was assumed to be current as of the date of survey submission.

Due to the small sample size of our dataset, we limited the negative binomial regression analysis to those local and workplace characteristics that indicated an association with COVID-19 rates in univariate analysis. We assessed the association between COVID-19 rates over the whole study period with these potential risk factors using four sets of models (M) that calculated incidence rate ratios (IRRs). M1 included analyses separately for: (i) industry subgroups; (ii) the background rate and 1 km deprivation (local factors); and (iii) number of workers, proportion working remotely, proportion working in close proximity (<2 m), and the presence of mechanical ventilation (workplace factors). M2 included the industry subgroups with local factors. M3 included the industry subgroups with workplace factors, and M4 included the industry subgroups with both local and workplace factors. The main analysis used manufacture of beverages as the reference group, since it had the median COVID-19 incidence rate. In sensitivity analyses, we calculated IRRs based on the mean COVID-19 rate for all industry subgroups as the reference, compared IRRs separately for T2 and T3 (T1 had too few cases), and included deprivation based on a 5 km radius around sites. We only included sites that had complete data for each covariate, ≥5 workers on site, and ≥5 sites within each industry subgroup (i.e. we excluded 'other'): $n = 53$ sites were included in analysis. Geospatial analyses were undertaken using QGIS (v3.10.1) and statistical analysis was completed in Stata (v16.1).

Results

Respondents, mainly health and safety (H&S) managers, from 33 companies covering 66 individual sites, completed the CaWS survey across the UK (see Supplementary Fig. S1, available at *Annals of Work Exposures and Health* online). COVID-19 cases were reported from the start of the pandemic (March 2020) through to the time of completing the survey (range: February–June 2021; 11.1–15.5 months). Respondents represented various industry subgroups, including grain milling/storage ($n = 16$), manufacture of malt ($n = 14$), manufacture of prepared meals ($n = 12$), manufacture of beverages ($n = 8$), distilling ($n = 5$), manufacture of baked goods ($n = 5$), and other ($n = 6$) (see Supplementary Table S1, available at *Annals of Work Exposures and Health* online). The number of workers at each site ranged from 5 to 1726, with a total of 15 563 workers across all sites. Over three quarters (52/66; 79%) of sites reported at least 1 positive case, with a total of 1068 COVID-19 cases across all sites. Lowest case rates were reported from sites working in distilling with an average of 0.9 monthly COVID-19 cases per 1000 workers; highest reported rates were in the sites working in grain milling/storage sector with an average of 6.1 monthly COVID-19 cases per 1000 workers (see Table 1; Supplementary Table S2, available at *Annals of Work Exposures and Health* online for characteristics by industry subgroup).

In the regression analyses, unadjusted models suggested initial differences in reported infection rates between industry subgroups, with IRRs ranging from 0.25 [95% confidence interval (CI): 0.07–0.85] for distilling to 1.92 (95% CI: 0.93–3.97) for grain milling/storage (Supplementary Fig. S2, available at *Annals of Work Exposures and Health* online). In fully adjusted models, all IRRs included the null value except for grain milling/storage [IRR = 2.10 (95% CI: 1.03–4.26)] (Fig. 1). Several local and workplace factors were related to decreasing risks of COVID-19 cases, including the proportion of remote workers [IRR = 0.78 (95% CI: 0.62–0.98)] and the proportion of workers in close proximity [IRR = 0.89 (95% CI: 0.81–0.98)]; higher numbers of workers were associated with an increased risk [IRR = 1.41 (95% CI: 1.07–1.86)] (Fig. 1). Some differences in these results were apparent in T2 and T3; for example, IRRs for grain milling/storage were not significantly increased and the presence of mechanical ventilation was associated with an increased risk in T3 (Supplementary Fig. S3, available at *Annals of Work Exposures and Health* online). Similar findings were obtained when based on the overall industry subgroup mean as the reference category (Supplementary Table S3, available at *Annals of Work Exposures and Health* online). Higher SES based on a 5 km radius was associated with a reduced risk [IRR = 0.80 (95% CI: 0.68–0.94)].

Table 1. Summary statistics for workplace factors collected in the CaWS survey for all sites ($n = 66$).

Factor	Median (range)/ *n* (%)
Industry subgroup	
Distilling	5 (8%)
Grain milling/storage	16 (24%)
Manufacture of baked goods	5 (7%)
Manufacture of beverages	8 (12%)
Manufacture of prepared meals	12 (18%)
Manufacture/storage of malt	14 (21%)
Other	6 (9%)
Positive COVID-19 cases: count per worksite	
Overall	4 (0–205)
March–June 2020 (T1)	0 (0–19)
July–December 2020 (T2)	2 (0–168)
January–June[a] 2021 (T3)	2 (0–64)
Local COVID-19 rate (per 100 000 population)	5529 (1097–10 085)
Missing	2 (3%)
Deprivation decile	5.9 (3.1–8.25)
Missing	2 (3%)
Number of permanent workers	72 (5–1726)
Missing	3 (5%)
Number of remote workers	6 (0–150)
Missing	2 (3%)
Sites in operation	65 (99%)
Operate in shifts	60 (91%)
Staggered breaks	59 (89%)
Number working in close proximity to others	1 (0–1500)
Proportion working indoors for ≥50% of shift	53 (80%)
Hygiene areas on site	
Basic	32 (48%)
Medium	38 (58%)
High	20 (30%)
Open windows and doors (≥50% of the time)	27 (41%)
Mechanical supply and exhaust	39 (59%)
Areas on site where work occurs at <18°C	40 (61%)
Areas on site where work occurs at >22°C	38 (58%)
Hearing protection zones within the facility	62 (94%)
Retail or public-facing area?	11 (17%)
Contacted by a public health authority	15 (23%)
Missing	4 (6%)
Regular employee testing	12 (18%)
Frequency of employee testing	
>Once per week	3 (25%)
Once per week	7 (58%)
Other	2 (17%)

[a]Respondents completed the survey from February to June 2021.

Discussion

Key results

We undertook a survey of 66 sites in the UK food and drink processing sector tracking positive COVID-19 cases from March 2020 up to June 2021. We observed variation in risks across industry subgroups, which were partially attenuated after adjusting for several local and workplace factors; risks for one subgroup (grain milling/storage) remained elevated. Certain local and workplace characteristics were related to higher infection rates, such as higher deprivation (5 km only), a lower proportion of remote workers, lower proportion of workers in close proximity, and higher numbers of workers overall.

Interpretation

It is not clear why rates were elevated in grain milling/storage sites after adjusting for various local and workplace risk factors, but it might be related to the response to the surge in demand for flour, particularly early in the pandemic (Do *et al.*, 2021). Workplace level COVID-19 risks appear to be associated with neighbourhood deprivation, but this is sensitive to the radius chosen: COVID-19 rates decreased with lower average deprivation in a 5 km radius, but this was not apparent with a 1 km radius. The immediate vicinity of sites may not reflect neighbourhoods in which workers live, thus larger areas of averaging, such as 5 km, may be more representative of residential deprivation. Risks with higher deprivation, while adjusting for background rates, could be related to areas where workers are exposed to greater transmission risks, such as living in crowded housing or taking shared/public transport to work (Baena-Díez *et al.*, 2020; Patel *et al.*, 2020). Sites with a greater proportion of remote workers had lower rates of COVID-19, suggesting that excess risks could be related to workplace, commuting, or other work-related factors. However, lower rates could be biased if remote workers were less likely to report a positive test result to their employer, which would artificially decrease calculated risks. As observed elsewhere (Contreras *et al.*, 2021), we found greater risks at sites with a higher number of workers, but, unexpectedly, risks were slightly lower at sites where more workers were in close proximity. This finding could possibly be related to the implementation of additional mitigation measures where work in close proximity was unavoidable, though we do not have data to support this. Nevertheless, we did not ascertain the number of people in close proximity working on the same shift.

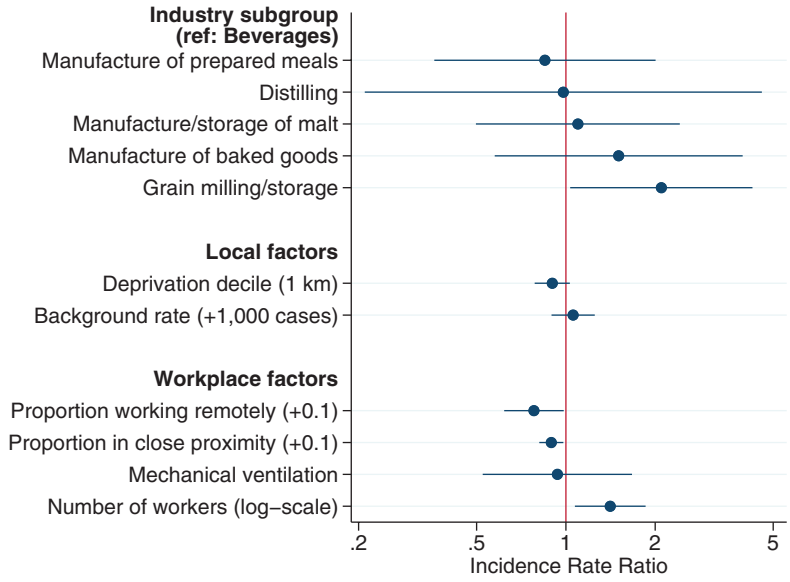

Figure 1. The IRRs for industry subgroups, local and workplace factors, adjusted for all covariates present (i.e. Model 4) (n = 53 sites).

Limitations

A limitation of this study is the modest number of responses, which also may have entailed self-selection issues involving either those who felt their companies were doing well, or, conversely, those who felt their industry most needed help with respect to COVID-19. Our survey commenced in early 2021, which was the peak of the second COVID-19 wave in the UK; thus, many H&S managers may not have had sufficient resources to participate. Although there were no facilities related to meat processing in our survey, these sites have been researched elsewhere (e.g. Dyal, 2020; Günther *et al.*, 2020; Herstein *et al.*, 2021). No data were collected on vaccine rates, as vaccines were only introduced to working age adults in the UK during T3 of the survey. Rate of vaccination is likely to be a confounding factor when comparing COVID-19 rates across groups.

Generalizability

We are not aware of any other studies examining different subgroups within the food processing sector. While it is difficult to generalize our findings, given our analysis was based on a small, self-selected sample, we did observe similar risk factors (e.g. higher deprivation, larger number of workers) to those previously identified in the literature. We will clarify and extend our results in stages 2 (structured interviews) and 3 ('deep dive' interviews) of CaWS.

Conclusion

Our analysis of a sample of the UK food and drink processing sector showed variation in COVID-19 infection rates across industry subgroups, with risks in one (grain milling/storage) remaining elevated after adjustment for local and workplace risk factors. Some of these characteristics also were related to infection rates, such as deprivation, the proportions of remote workers and workers in close proximity, and the overall number of workers.

Supplementary data

Supplementary data are available at *Annals of Work Exposures and Health* online.

Funding

This work was supported by funding from the PROTECT COVID-19 National Core Study on transmission and environment, managed by the Health and Safety Executive on behalf of HM Government of the United Kingdom of Great Britain and Northern Ireland.

Acknowledgements

We are grateful to the food and drink processing associations, federations, and companies that participated in this research.

Conflict of interest

The authors declare no conflict of interest relating to the material presented in this Article. Its contents, including any opinions and/or conclusions expressed, are solely those of the authors.

Data availability

The data underlying this article cannot be shared publicly to maintain the confidentiality of the companies that participated in the study.

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