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Short Communication

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Short Communication

The Development of a Covid-19 Control Measures Risk Matrix for Occupational Hygiene Protective Measures

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Abstract

The British Occupational Hygiene Society (BOHS) Covid-19 Working Group developed a control banding matrix to provide guidance for employers and others to help assess the risks of Covid-19 infection during the pandemic. The matrix was based on occupational hygiene principles and the judgement of the occupational health practitioners involved; since objective data on workers' exposure were unavailable. Users of the matrix identify one of five exposure categories based on generic job descriptions and example occupations, and these categories are linked to generic guidance on interventions at source, on the exposure pathway and for individual workers. The risk matrix was published on the BOHS website and the guidance has been downloaded more than 2000 times. The matrix has had limited evaluation for reliability, but the data suggest that the highest exposure ranked jobs were associated with higher age-standardized mortality in Britain during the pandemic. However, there was considerable variability in exposure assignments between assessors, which underlines the need for the control guidance to be precautionary. The BOHS calls on academic researchers to undertake further work to validate the reliability of the tool.

Keywords: control banding; Covid-19; pandemic; SARS-CoV-2

Introduction

The onset of the Covid-19 pandemic was primarily viewed by governments and society as a public health risk, although occupational health practitioners were quick to highlight the potential risks for workers (Burdorf *et al.*, 2020; Sim, 2020), and to pose pertinent

What's Important About This Paper?

Owing to the lack of methods for assessment of exposure to SARS-CoV-2 and COVID-19 risk, the British Occupational Hygiene Society COVID-19 Working Group developed a control banding matrix to provide guidance for employers and others. This work describes the development of the matrix, and limited evaluation suggests that jobs ranked as having the highest exposure were associated with higher age-standardized mortality in Britain. The tool will continue to be updated as new evidence emerges about Covid-19 risks among workers, but further assessment of the tool's reliability is necessary.

questions for worker protection (Semple and Cherrie, 2020). The national responses tended to be driven by public health/infection control and health service concerns. As far as worker protection was concerned, official guidance tended to focus almost exclusively on healthcare and later social care (ECDC, 2020), and mostly standard infection control measures such as hand hygiene and the selection of personal protective equipment (PPE), including respiratory protective equipment (RPE). There was little consideration of other more reliable control measures such as local ventilation.

For RPE there is evidence of the overwhelming superiority of filtering face piece respirators (FFRs) over surgical masks to protect against airborne viruses (Gawn *et al.*, 2008), and guidance from the British Health and Safety Executive (HSE) recommends FFRs to contend with threats from biological agents (HSE, 2013). Nevertheless, when the pandemic struck, assumptions were made regarding risk pertaining to so-called 'Aerosol Generating Procedures' (AGPs) on somewhat tenuous grounds (Wilson *et al.*, 2020) and the extant guidance was not implemented. In spite of the initially scant knowledge of the extent of aerosol transmission (PHE, 2020), limited heed was given to precautionary principles (Cherrie *et al.*, 2020). For the vast majority of workplaces, there was limited guidance on 'Covid-secure' measures to be applied (HSE, 2020), and that which was available was largely based on the public health measures that were being followed.

In Britain the Control of Substances Hazardous to Health (COSHH) Regulations apply to hazardous biological agents such as SARS-CoV-2. The legislation specifies a clear imperative for prevention, and if that is not reasonably practicable, to adequately control exposure to hazardous substances; PPE should only be used when other measures cannot properly protect the health of workers. The regulations set out eight generic principles of good control practice that should guide the choice of effective control options, which are sometimes codified into a hierarchy of controls that recognizes measures applied at the source are likely to be most effective (HSE, 2015). The British Occupational Hygiene Society (BOHS) recognized the need to supplement the extant guidance by producing authoritative advice on worker health protection from Covid-19. The aims were 2-fold. Firstly, to produce rapid guidance at a relatively granular and job-specific level that could be applied to a wide range of jobs to determine precautionary control measures. Secondly, to present this output for scientific debate, testing, and iteration.

Methods

A control banding matrix based on the occupational hygiene principles in the hierarchy of control was developed: https://bohs.link/risk-matrix. The source–pathway–receptor model was employed as the basis for defining control options, as has been done in other exposure modelling, e.g. Fransman *et al.* (2011) (Fig. 1; source circle, receptor triangles and rectangles, and lines represent the pathways). The matrix recognized that in an emergency and time-sensitive context measures involving limited modifications to the workplace were more practicable than the immediate introduction of engineering controls such a local ventilation. It was intended to be an easily understood aid for occupational hygienists and others engaged in providing occupational health and safety advice to employers.

The methods used in development of the matrix were mixed and had to steer a balanced middle course. On the one hand, the ideal best quality source of information is systematic evaluation of good science, such as traditionally offered by Cochrane reviews (Verbeek *et al.*, 2020) but, in spite of the best efforts of the reviewers, this left many pragmatic and urgent questions unanswered because of lack of evidence. On the other hand, a consensus view, where objective data were still lacking, while acting with relative haste could result in an output of limited quality. A professional and academic working group was convened for the purpose by the BOHS.

There are limited data about the exposure of workers to the SARS-CoV-2 virus. Most research concerns virus

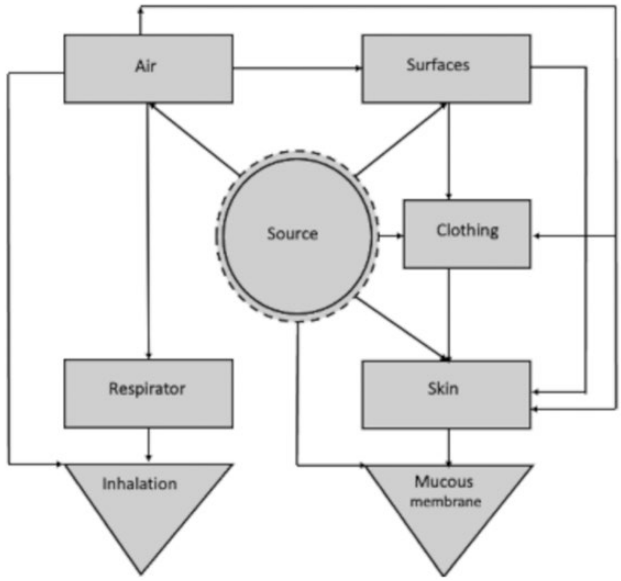

Figure 1. Source–receptor model for SARS-CoV-2.

in healthcare settings, where air concentrations and surface contamination were generally low (Cherrie *et al.*, 2021). It is unclear why this is the case, but it may reflect good general ventilation and regular cleaning regimes in these workplaces. Very limited data are available for public transportation, which also show low levels of air and surface contamination (Cherrie *et al.*, 2021). There are no data on environmental contamination for other workplace environments. In addition, there is no clear picture of which route of exposure is most important in determining risk of Covid-19 infection: inhalation, fomite transmission to mucous membranes, or direct droplet spray into the face.

The occupational groups listed in the risk matrix were initially selected to represent 'key workers', but the groups were extended to include other jobs who were clearly at risk of infection such as nail bar workers. Each of these generic groups was then populated with example job titles that the Working Group considered appropriate for inclusion. The aim was to provide a range of occupational groups that would enable the user in an individual workplace to find a group that was at least somewhat analogous to their situation, should their specific occupational group not be explicitly described.

Independently, five exposure categories were defined (E0–E4), which were linked to associated control bands (N = normal public health controls, and bands A–D). The exposure categories were identified from judgement about the likelihood of and the daily duration of exposure. Each exposure rank was associated with a control band that linked to generic guidance on the interventions at source, on the exposure pathway and at the individual worker (receptor). The scheme is shown in Table 1.

This approach was informed by developments being undertaken in the USA by Sietsema *et al.* (2019), some of which were then published in this journal (Brosseau *et al.*, 2021). These initiatives dealt with aerosol transmission, but the present matrix has been extended to consider other routes of exposure, such as large droplets and fomite transmission.

As epidemiologic data became available, such as the bulletins of the Office for National Statistics (ONS, 2020a, 2021), these were taken into account in the matrix development, providing support for the assigned exposure categories. For example, to investigate the suitability and reliability of the matrix we extracted age-standardized Covid-19 mortality data for males aged 20 to 64 in England and Wales for the period March

Table 1. Exposure groups (E) and control bands (N, A–D) derived from likelihood and duration of exposure.

Likelihood	Daily duration		
	D1 (0–3 h)	D2 (3–6 h)	D3 (>6 h)
L0 (no exposure)	E0/N	E0/N	E0/N
L1 (exposure unlikely)	E1/A	E1/A	E1/A
L2 (possible exposure)	E2/B	E2/B	E3/C
L3 (exposure likely)	E2/B	E3/C	E4/D

to December 2020; only occupations (4-digit SOC) with 10 or more deaths were included (ONS, 2021). For each of these occupations four assessors used the matrix to assign an appropriate exposure rank. The assessors comprised three Chartered Occupational Hygienists and an occupational health clinician, all with extensive experience of occupational hygiene and all Past Presidents of the BOHS. The assessors had been engaged in the matrix development.

Results

Fig. 2 shows the age-standardized death rate by median exposure rank from the four assessors. It is clear that the assessors can in general separate higher (rank E3 and 4) from lower risks (rank E1 and 2) but are poorer at distinguishing within these broad groups. We also assessed inter-rater reliability using Fleiss kappa calculated using the R package 'irr'. Overall, the kappa was 0.35 suggesting fair agreement, although within the individual exposure categories the kappa varied from 0.21 (E1) to 0.76 (E4).

In addition, the ONS published data on the likely proximity of workers to others by adapting data from a survey of US workers (ONS, 2020b). Fig. 3 shows data for the median exposure rank from the four assessors to the proximity scores (a continuous measure from zero—'I don't work near other people', 25—'I work with others but not closely (e.g. private office)', 50—'Slightly close (e.g. shared office)', 75—'Moderately close (at arm's length)' to 100 'Very close (near touching)' (https://www.onetonline.org/find/descriptor/result/4.C.2.a.3). It is clear that as the median exposure rank increases the score for proximity to others on average also increases, and from this we conclude that the risk matrix embodies elements that reflect the 'social distance' between individuals at work.

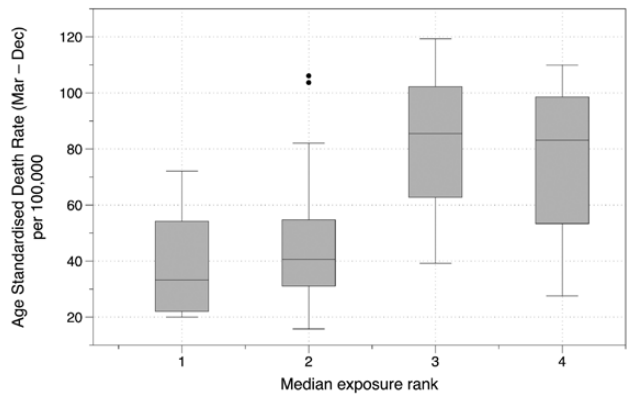

Figure 2. Age-standardized death rate involving Covid-19 in men aged 20–64 (per 100 000) in England and Wales by median exposure rank.

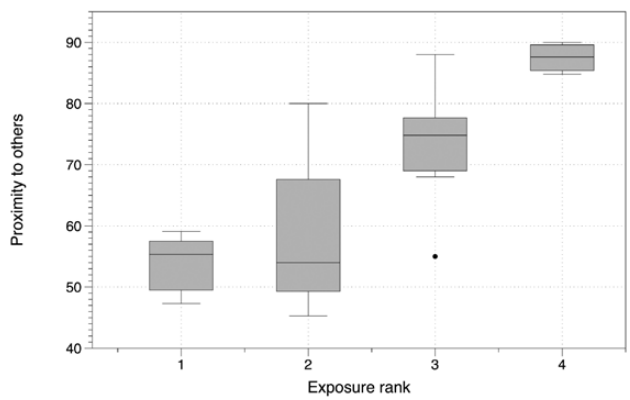

Figure 3. Proximity score for occupations by median exposure rank.

ONS articulated the limitations of the analyses they undertook, and these have been recognized by the Working Group. In the mortality data, these limitations include numerator bias, such as from deaths which were reported to the coroner because of suspicion of occupational causation but not yet registered or analysed by the ONS (Agius, 2020a). Moreover, important determinants of mortality such as socio-economic status and comorbidity were not taken into account (ONS, 2021). A comprehensive review of the ONS data and other epidemiologic research showing the strength of association between occupations and the risks of infection with or death from Covid-19 has been published by the Industrial Injuries Advisory Council (IIAC, 2021). Nevertheless, as a further application of precautionary principles the suggestions of risk for different occupations from these crude analyses should not be dismissed.

The Covid-19 control measures risk matrix was published online at https://bohs.link/risk-matrix on 23 July 2020 and was accessed over 2100 times by the end of 2020. By way of a key example: Care workers (Generic Occupational Groups 1, 2, and 3) are all assigned to exposure rank E4 and control band D. Control at source for these groups typically comprises isolation of patients, restricted staff access, regular surface disinfection, along with a visor or face covering worn by the patient. Transmission controls can include local ventilation close to the source of any aerosol generating medical procedures, good general ventilation along with regular surface disinfection. Recommended receptor controls may include the use of powered air purifying respirators, but if this is not feasible the use of high-efficiency respirators, e.g. FFP3, and visor, gown, gloves, and/or hygiene—hand washing/hand sanitizing. The recommended controls for other Generic Occupational Groups follows a similar pattern.

Discussion: strengths and weaknesses of the matrix

There was a very limited evidence base available to construct the matrix and the subsequently published exposure data have not yet added appreciably to our knowledge of risk outside healthcare settings. The matrix was mostly based on the expert judgement of the Working Group supported by a conceptual analysis of the source–receptor pathways for infection. Nevertheless, the reliability of the matrix is supported by the Covid-19 mortality data from the England and Wales and data on the likely proximity of workers in different occupations. Overall, there was fair agreement between assessors using the matrix, but substantially better agreement in the assignment of high (E3 and 4) exposure ratings. It is simple and easy to use.

During development of the risk matrix there was much discussion over the granularity of the control options provided. For example, the meaning of 'regular' surface cleaning was not defined, nor details of the type or design of ventilation. The expectation was that the matrix should serve as a guide to facilitate local decision making, with the specifics of the control measures being worked out by occupational health professionals on the ground.

The risk matrix does not consider whether different routes may be more or less important in infection transmission, e.g. a cough directly in the face of a nurse from a Covid-19 patient may be more likely to cause infection than touching surfaces in public transport. This limits the usefulness of the categorizations in identifying appropriate risk management strategies, although users are provided with a range of control options. Users must still use professional judgement in selecting the best approach for each scenario.

Risk is in large part determined by the background prevalence of Covid-19 infection in the population encountered by the worker, which changes over time and between locations, and so an individual's work tasks are not the only factors involved. The matrix does not account for this but clearly the background frequency of Covid-19 in the community should be taken into account when using the tool. Also, the tool does not take account of the physical health limitations of some workers, the type of PPE that they can tolerate or their clinical susceptibility to Covid-19 (Agius, 2020b). In this context, an important tool that is complementary to the BOHS' Covid-19 risk matrix is the estimation of 'Covid-age' (Coggon *et al.*, 2020), which considers information about an individual such as their age, gender, and relevant diseases. Thus, the risk matrix described here, along with Covid-age and indices of risk in the community, might provide a comprehensive indication of the Covid-19 risk for a working adult.

The Working Group considered that the matrix was broadly precautionary in its recommendations for control options, which often go beyond what many Governments or their agencies, such as Public Health England (PHE, 2021), or the World Health Organisation (WHO, 2020) have recommended. This is because occupational exposures are viewed as an additional exposure burden, overlying the community exposure, and one which employers have a legal and moral obligation to address. In the spirit of control banding solutions in general the recommendations are designed to be protective in situations where there is uncertainty. For example, in E3/C, which comprises public facing workers with a high risk of face-to-face contact—e.g. teachers,

taxi drivers, and shop workers, the matrix recommends use of FFP2 respirators, good general ventilation, and appropriate use of physical barriers. Since original publication of the risk matrix the amount of guidance and advice has improved, but the generic precautionary guidance contained in the matrix is not available elsewhere.

The BOHS Covid-19 risk matrix has not yet been formally evaluated. Feedback so far has suggested that it was a timely contribution and found to be of great assistance to those tasked with developing a response at the level of an individual workplaces. However, the BOHS calls on academic researchers to undertake work to validate the reliability and reproducibility of the tool, which could be undertaken by comparing the outputs with job-exposure matrices being developed for epidemiological studies or comparing with Covid-19 infection risks within occupational groups from such studies. There is also a need to extend the work described here to assess the repeatability of assessments, both between assessors and over time for the same assessors. This work could also help identify training needs for the use of the tool. The BOHS has agreed to continue to support and develop the tool through the pandemic and the Working Group will regularly review the evidence to sustain a reliable matrix.

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Conflict of interest

The authors declare no conflict of interest.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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