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EDITORIAL

Assessment of workers' personal vulnerability to covid-19 using 'covid-age'

As countries adapt to the longer-term challenges of Covid-19, occupational health professionals increasingly are being asked to advise on the fitness for work of patients who might be unusually vulnerable to the disease because of their age, ethnicity and/or comorbidities. The risk of contracting Covid-19 through work will depend on its prevalence in the local community; the extent to which the job entails either close proximity to people who could be carrying the infection or contact with material that might be contaminated by the virus; the effectiveness of any measures to reduce transmission (such as barriers or personal protective equipment); and personal immunity (e.g. as a consequence of previous infection, or perhaps in the future, immunization). More important for the individual, however, is the risk of developing serious or fatal Covid-19, which will also depend on his/her personal vulnerability should infection occur.

Early in the course of the Covid-19 epidemic, the UK government issued guidance on vulnerability from comorbidities [1,2]. More recently, others have published guidance on risk reduction for healthcare workers [3] and the broader management of return to work in the face of health risks from Covid-19 [4]. None of these documents attempts to quantify risks associated with specific comorbidities, but research is now emerging that allows more detailed and reliable assessment of vulnerability to Covid-19. This has enabled us to develop an evidence-based risk model that can be used to estimate personal vulnerability. The tool, which is intended principally to assist decisions on occupational placement of workers in the UK, was first published as a freely available online resource on 20 May 2020, and is being updated and refined periodically as relevant new data become available [5].

Our aim was to assess and compare risks of fatality in people who contract SARSCov-2 infection, according to their age, sex, ethnicity, smoking habits and various comorbidities. In preliminary searches of the published literature, no evidence could be found on risks of fatality in representative samples of people infected by the virus (including those with asymptomatic infection). However, analyses of mortality from Covid-19 in the general population could be expected to provide good proxy measures of relative risk, provided the likelihood of contracting infection did not vary importantly according to the risk factors under consideration (as might occur, for example, because of selective shielding by people with certain comorbidities). In addition, estimates of risk might be possible if data could be found on fatality rates by comorbidity in patients admitted to hospital because of Covid-19, and then combined with information about the prevalence of the same comorbidities among hospitalized Covid-19 patients as compared with the general population.

Because of the urgency to improve on earlier advice, we selectively sought papers that would provide the strongest evidence relevant to the UK and did not attempt systematically to search for, and review, all published data that might bear on the risks that we were trying to characterize. In this respect, one report initially stood out as particularly suited to our purpose. Produced by the OpenSAFELY (OS) collaborative, it presented first results from a cohort study of more than 17 million adults registered with English general practices and followed between 1 February and 25 April 2020 [6]. It used multivariate Cox regression to estimate mutually adjusted hazard ratios for death in hospital with confirmed Covid-19 in relation to risk factors determined from pseudonymized individual primary care records. As well as sex, age, ethnicity, smoking habits and multiple comorbidities, these analyses adjusted for social deprivation (which might in part indicate higher exposure through domestic crowding) and for administrative region (to allow for varying rates of infection in different parts of the country).

This study included a substantial proportion of the adult population of England, and was based on more than 5000 deaths attributed to Covid-19. Moreover, information about risk factors came from data recorded before the onset of infection, which reduced the possibility of ascertainment being biased in relation to the outcome. Nevertheless, we sought to check the plausibility of its findings, using data from four independent sources: Office for National Statistics (ONS) data on mortality from Covid-19 by sex and age in England and Wales during March 2020; ONS estimates of sex-specific odds ratios for coronavirus-related deaths by ethnic group in England and Wales; a report on outcomes, including mortality, in a cohort of 16 749 patients with Covid-19 admitted to hospitals in England,

Table 1. Vulnerability from risk factors expressed as equivalence to added years of age

Risk factor	Relative risk	Equivalent added years of age[a]	Robustness of risk estimate
Female sex	0.6	-5	Moderately robust
Ethnicity			
Asian or Asian British	1.5	4	Moderately robust
Black	1.7	5	Moderately robust
Mixed	1.4	3	Provisional
Other non-white	1.3	3	Provisional
Body mass index (kg/m^2)			
30–34.9	1.3	3	Provisional
35–39.9	1.6	5	Provisional
≥40	2.4	9	Provisional
Hypertension (according to actual age, years)			
20–26	3.3–3.6	12	Provisional
27–33	3.0–3.3	11	Provisional
34–39	2.7–2.9	10	Provisional
40–44	2.4–2.6	9	Provisional
45–49	2.2–2.4	8	Provisional
50–54	2.0–2.1	7	Provisional
55–57	1.8–1.9	6	Provisional
58–61	1.6–1.8	5	Provisional
62–64	1.5–1.6	4	Provisional
65–67	1.3–1.4	3	Provisional
68–70	1.2–1.3	2	Provisional
71–72	1.1	1	Provisional
≥73	1	0	Provisional
Heart failure	2.2	8	Provisional
Other chronic heart disease	1.3	3	Provisional
Cerebrovascular disease	2.2	8	Provisional
Asthma			
Mild (no requirement for oral corticosteroids in past year)	1.1	1	Moderately robust
Severe (requiring oral corticosteroids in past year)	1.4	3	Moderately robust
Chronic respiratory disease (excluding asthma)	1.9	6	Moderately robust
Diabetes			
Type 1			
HbA1 ≤58 mmol/mol in past year	2.0	7	Moderately robust
HbA1 >58 mmol/mol in past year	2.7	10	Moderately robust
HbA1c unknown	3.3	12	Moderately robust
Type 2 and other			
HbA1 ≤58 mmol/mol in past year	1.5	4	Moderately robust
HbA1 >58 mmol/mol in past year	2.0	7	Moderately robust
HbA1c unknown	2.3	8	Moderately robust
Chronic kidney disease			
Estimated GFR 30–60 ml/min	1.5	4	Moderately robust
Estimated GFR < 30 ml/min	3.0	11	Moderately robust
History of dialysis or end-stage renal failure	3.7	13	Moderately robust
Non-haematological cancer			
Diagnosed <1 year ago	1.7	5	Provisional
Diagnosed 1–4.9 years ago	1.2	2	Provisional
Diagnosed ≥5 years ago	1	0	Provisional
Haematological malignancy			
Diagnosed <1 year ago	2.8	10	Provisional
Diagnosed 1–4.9 years ago	2.5	9	Provisional
Diagnosed ≥5 years ago	1.6	5	Provisional
Liver disease	1.8	6	Provisional
Chronic neurological disease other than stroke or dementia[b]	2.6	9	Provisional
Organ transplant	3.6	12	Provisional
Spleen diseases[c]	1.4	3	Provisional
Rheumatoid/lupus/psoriasis	1.2	2	Provisional
Other immunosuppressive condition[d]	1.8	6	Provisional

[a]Added years for hypertension are calculated from relative risks before rounding.
[b]Motor neurone disease, myasthenia gravis, multiple sclerosis, Parkinson's disease, cerebral palsy, quadriplegia, hemiplegia and progressive cerebellar disease.
[c]Includes splenectomy, or spleen dysfunction (e.g. from sickle cell disease).
[d]Includes HIV, conditions inducing permanent immunodeficiency (ever diagnosed), aplastic anaemia, and temporary immunodeficiency recorded within the past year.

Wales and Scotland during 6 February to 18 April 2020 [7]; and data on the prevalence of comorbidities by sex and age in samples of people (intended to be nationally representative) from recent rounds of the Health Survey for England.

To produce the first iteration of our risk model, we abstracted hazard ratios for risk factors of interest from the OS report, and where possible checked their plausibility against data from the other sources mentioned above. Subsequently, new evidence became available from several further papers, including most notably a report on associations of diabetes with mortality from Covid-19 in a cohort of 61 million patients registered with English general practices [8], and another on risk factors for death related to Covid-19 in a subcohort of more than 3 million patients with

diabetes [9]. Together, these allowed risk estimates for a finer classification of diabetes by type and level of control, checks on possible interactions between diabetes and other risk factors, and refined risk estimates for cardiovascular disease.

The relative risks adopted for our risk model, as at 16 July 2020, are shown in Table 1, together with qualitative assessments of the strength of evidence ('robustness') on which each estimate of risk is based. Smoking was not included in the model because, after allowance for other factors, it appeared not to carry any material increase in risk.

A notable feature of Covid-19 is that mortality rates increase exponentially with age. In these circumstances, vulnerability from other risk factors can conveniently be expressed in terms of the added years of age that would give an equivalent increase in risk [10]. Table 1 quantifies the vulnerabilities associated with demographic variables and comorbidities as age equivalents as well as relative risks. If it is assumed that when risk factors are present in combination, their relative risks multiply (the normal default assumption in regression analyses such as in the OS report), then combined effects can be estimated by summing the age equivalent for each. Moreover, by adding the summed age equivalents to the person's true age, it is possible to generate a summary measure of personal vulnerability, which we have termed 'Covid-age'. It represents the age of a healthy white male with equivalent vulnerability (white males being the largest demographic group in the UK workforce).

Covid-ages can be translated into estimated case–fatality rates. This is complicated by uncertainties about the prevalence of asymptomatic infection, but from the limited data that are available, it is estimated that a Covid-age of 47 years might correspond approximately to a case fatality rate of 2 per 1000 [5]. For each additional 10 years of age, case fatality increases by a factor of 2.8.

Our analysis has important limitations. Currently, the risk assessments are derived largely from a single study, albeit with checks on plausibility using other sources. Data on some risk factors were incomplete and, although the study was large, its findings, in particular for rarer comorbidities, are liable to statistical uncertainties. Risks associated with some comorbidities may have been inappropriately attenuated by adjustment for deprivation. In the absence of evidence to the contrary, we have assumed as a first approximation that relative risks from different factors multiply, but that may not always be true. For example, evidence has now emerged that although hypertension is not associated with higher mortality when results are averaged across all ages, it carries an increased risk in younger adults [11]. Also, some risk estimates may have been liable to residual bias because of differences in exposure to infection.

A further limitation is the heterogeneity of some categories of comorbidity. For example, chronic pulmonary disease aggregates various disorders, each with a range of severity. In the future, data should emerge that allow evidence-based risk assessments for more specific sub-categories of disease. Meanwhile, clinical judgement should be applied when considering how risks might vary within a broader, aggregated category of comorbidity, taking as a starting point the estimated risk for the category as a whole. Similarly, clinical judgement is required for comorbidities on which epidemiological evidence is not yet available.

We expect that some of these limitations can be addressed as further evidence becomes available. Meanwhile, we believe that our assessment of vulnerability offers an improvement on what has been available previously. We caution against simplistic rules for decisions based only on the risks that it estimates. It does not remove the need for clinical judgement, and there are other important considerations when managing occupational risks from Covid-19—for example, the practicability of different possible control measures, the expected prevalence of infection in the local population, the personal value judgements of the individual worker and prevailing advice from government (which may be driven by a need to control demands on healthcare services as well as individual risk). With these caveats, we hope that it will prove a useful contribution to decisions about fitness for work during the Covid-19 pandemic in the UK adult population.

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