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Commentary

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Estimating occupational disease burden: a way forward

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Abstract

Estimates of occupational disease burden provide important information on which effective policy and regulations can be developed. However, there is no direct way that these data can be obtained, and most burden estimates are derived by merging different data from diverse sources to synthesize estimates of the number of people made ill or who have died from workplace exposures. In recent years, several research groups have published estimates of occupational health burden at national or global scales; these are not always consistent. The World Health Organisation and the International Labour Organisation have taken on the task of producing occupational disease burden estimates for several workplace agents, which we assume are to be seen as the definitive global, regional, and national data. In this commentary, we critique the WHO/ILO approach for their estimates of the non-melanoma skin cancer burden from solar ultraviolet radiation and some of their results for hazardous particulates. We provide recommendations for researchers undertaking occupational burden estimates that they should report along with their data.

Key words: occupational cancer; workplace; burden; exposure prevalence; epidemiology; risk; NMSC

Background

Understanding the incidence and mortality from occupational disease, i.e. the burden of disease from work, is important. These data, at national or global level, provide insight into the relative importance of occupational health within the broader priorities for public health, and they provide information about the relative strategies and priorities for the prevention or control of work-related health hazards. The British cancer burden study, the results of which were published around ten years ago, helped to shape the national policy and provided a renewed focus on cancer caused by work, both in Britain and elsewhere (Rushton et al. 2012; Cherrie et al. 2017). Initiatives at an international level can similarly provide stimulus to global policy.

A number of research groups have attempted to evaluate the global burden of disease from a range of occupational risk factors. Takala et al. (2023) published estimates for the global, regional, and country-level work-related burden of diseases and accidents for 2019. They attempted to cover a wide range of diseases and risk factors, with 120 combinations of exposure and outcome included. It was concluded that there were 2.9 million deaths associated with work, with around 90% due to work-related diseases. In their estimate, there were 843,000 deaths from work-related cancers (over 45 substance/occupation-disease pairs as definite and probable carcinogens), including 7,146 from melanoma and skin cancer. The Global Burden of Disease (GBD) collaboration published lower estimates for the overall global occupational mortality and cancer mortality (in 2016, 1.5 million deaths and 349,000 cancer deaths, from exposure to 14 carcinogens where the evidence for carcinogenicity was strong); they did not include skin cancers in their estimates (GBD 2016 Occupational Risk Factors Collaborators 2020). The Global Population Attributable Fraction for occupational cancer was 3.4% in the GBD study and 8.4% in Takkala and co-workers' work. Clearly, the headline estimates for

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deaths from occupational exposures depend strongly on which occupational exposures are considered associated with disease. Identifying the strength of the evidence on causation when presenting the results from burden studies is important. However, it could be argued that including agents that are "probable" occupational carcinogens will encourage regulators to intervene earlier to reduce risks.

Most of the diseases that are considered in burden studies have multiple causes, of which the workplace exposure is just one. There are, therefore, no directly collected statistics that can be used to compile occupational burden estimates. It is necessary to indirectly infer the occupational disease burden using data from many disparate sources, including about the number of individuals employed in potentially exposed industries and jobs, the prevalence of occupational exposure among these individuals, and the relative risk of death or disease of the exposed workers (compared to unexposed) based on data from epidemiological studies and other information. It is important to ensure that these data sources provide information that is comparable and compatible with the objectives of the study. For example, data about the exposure prevalence should be consistent with the relative risk estimates from epidemiological studies, i.e. they should both reflect the same underlying population at risk and similar intensity and duration of exposure.

The recent initiative from the World Health Organization (WHO) and the International Labour Organization (ILO) is particularly important (Pega et al. 2022) as it will inevitably drive global policy on workplace health. The WHO/ILO estimates the number of deaths and the loss of health, as disability-adjusted life years, caused by a wide range of occupational risk factors. These data are provided as global, regional, and national estimates, by sex and age group. In 2016, they estimated that there were 1.88 million deaths globally from 19 selected occupational risk factors (Pega et al. 2022). Around 290,000 deaths were from cancers attributed to exposure to 13 carcinogens; these data are lower than both of the earlier cited estimates. Burden estimates for other diseases and exposures are still to be published.

Confidence in the reliability of burden estimates can only come from a careful justification of the methodology and data sources used, and the data are strongly dependant on the included occupational risk factors. The aim of this commentary is to initiate a debate about best practice in undertaking and verifying occupational disease burden estimates, based on a critique of the WHO/ILO assessment of non-melanoma skin cancer (MMSC) burden from occupational solar ultraviolet exposure and the corresponding data for crystalline silica, asbestos and other dusts in relation to fibrotic lung disease and chronic obstructive pulmonary disease (COPD).

Non-melanoma skin cancer burden from work

In a recent article, WHO/ILO group presented estimates for the global, regional, and national burdens of non-melanoma skin cancer (NMSC, although now more correctly called keratinocyte carcinoma, comprising squamous cell carcinomas squamous cell carcinoma (SCC), basal cell carcinomas basal cell carcinoma [BCC], and other rarer types) attributed to occupational solar ultraviolet radiation exposure (Pega et al. 2023). The data were for the years 2000, 2010, and 2019, by age and sex. It was estimated that worldwide in 2019, there were almost 19,000 deaths from NMSC attributable to work outdoors in the sun.

The authors estimated that globally one-in-three of all deaths from NMSC can be attributed to outdoor work in the sun (WHO 2023). Further, they state that "between 2000 and 2019, skin cancer deaths attributable to occupational exposure to sunlight almost doubled," although in our opinion, this is more likely due to an increase in the NMSC deaths from all causes rather than just from work-related factors. Based on the research, the WHO has called for more action to protect workers from working outdoors (WHO, 2023). We do not dispute the need for governments to be more proactive in regulating the risks from occupational solar UV exposure, but we consider the basis for the recommendation to be biased to show a greater proportion of NMSC deaths being caused by work than is likely.

Data are available for individual countries in a supplementary file linked to the publication. For the United Kingdom, these estimated death data differ to other authoritative estimates and appear to us to be improbably high. For 2019, it was estimated by Pega et al. that there were 206 deaths from NMSC attributable to outdoor work and the corresponding figure for 2000 was 87 (attributable fraction 19%). These data are in contrast to the figure published by the British Occupational Cancer Burden Study Group of 13 deaths, nominally for 2005, with a PAF of around 4% (Young et al. 2012). The estimated deaths for the United Kingdom from Pega et al. for 2000 are greater than those for France (64 deaths) and Spain (80), both of which are at lower latitudes with more sun exposure than the United Kingdom. It is known that the risk for NMSC, both BCC and SCC, increases with decreasing latitude (Bauer et al. 2011; Schmitt et al. 2011).

Pega et al. did not compare their data with other national occupational cancer burden estimates for NMSC because these studies only reported incidence data (Fritschi and Driscoll, 2006; Peters et al. 2019), and for diseases where most individuals affected survive, it is probably more appropriate to report incident cases rather than mortality. It would have been possible for Pega et al. to compare their data with mortality estimates derived from cancer survival data and the incidence burden. For example, Peters et al. (2019) estimated there were 4,556 cases of NMSC in 2011 attributable to occupational exposure to solar UV in Canada. According to the Public Health Agency of Canada 76,100 Canadians were diagnosed with NMSC (in 2014), and 440 Canadians died as a consequence, crudely around 0.6% of all cases (Public Health Agency of Canada 2019). Using the cancer survival data and the result from Peters and colleagues, around 25 workers may have died yearly from NMSC in Canada as a consequence of their occupation. This is around a fifth of the number estimated by Pega et al. (114 deaths in 2010). We understand it is difficult to directly validate occupational cancer burden estimates, so comparison with other independent estimates provides important indirect confirmation that data are reliable.

In relation to the different results from the British and WHO/ILO studies, Pega and colleagues wrote that the "differences may be due to different data sources and methods," although they do not elaborate. They rely on a review of the epidemiological literature to identify a relative risk of 1.6 for NMSC death associated with any high occupational exposure (WHO 2021), which they apply to workers from all countries around the world. They chose this value despite it being based on incidence studies and the WHO's review conclusions that there was insufficient evidence in the literature to assess "the direction of the effect estimate with confidence," i.e. it was unclear from the data whether solar UV increased the risk of NMSC mortality. Young et al. (2012) selected lower relative risk estimates for the United Kingdom (outdoor workers: 1.41, farmers: 1.20, and mixed exposure: 1.03). There were also differences in the number of workers "at risk," with Pega et al. estimating that around 21 million workers (43.8% of the UK adult population) were occupationally exposed over the relevant risk time window, while Young et al. estimated only 5.5 million persons. A recent survey of workers in Europe has shown that 20.8% were assessed to be exposed to solar UV radiation in their last working week in winter, although much less than 1% had exposure assessed as high—perhaps unsurprising in winter (Cavet et al. 2023). Young et al. also took account of employee turnover in what the authors describe as a "risk exposure period," while Pega et al. include all those with at least one year of exposure during the risk time window. Consequently, they include almost half of the adult population in the United Kingdom as occupationally exposed to UV and at risk of death from NMSC.

The risk of NMSC is associated with cumulative lifetime exposure to solar UV radiation, and there are epidemiological studies demonstrating exposure–response relationships for both BCC (Bauer et al. 2011) and SCC (Schmitt et al. 2011). Solar radiation exposure in the United Kingdom is low, partly because of latitude and partly climate. For example, the annual average UV Index (UVI) in London is around 4.6, whereas the corresponding figure for Paris is 5.2 and for Madrid is 7 (Nomadseason 2023). Using measurements for occupational UV exposure for UK outdoor workers and the published exposure–response data from the articles by Bauer et al. and Schmitt et al., we have estimated that outdoor workers in the United Kingdom would, on average, double their risk of being diagnosed with BCC after 28 years and for SCC after 22 years of outdoor work (Cherrie and Cherrie 2022). It takes a long duration of occupational UV exposure in the United Kingdom to importantly increase the risk of NMSC. However, Pega et al. include many workers with short duration of outdoor work (almost half of the adult population) and apply a relatively high relative risk of NMSC death to this group resulting in more than 6-fold higher estimates of annual NMSC deaths from occupational exposure than reported by Young et al.

In our opinion, the WHO/ILO estimates of NMSC deaths linked to occupational UV exposure in the United Kingdom, and possibly Canada, are unrealistic and considerably overstate the true mortality burden. It is unclear whether the estimates for other countries are more accurate and precise.

Dust and fibres

We have previously criticized the WHO/ILO methodology because of concern about likely overestimation of the prevalence of exposure to respirable crystalline silica, asbestos, and coal dust (Kromhout et al. 2023). These authors (Schlünssen et al. 2023) proposed assessing the exposure prevalence based on the results from published measurement data where the proportion of data above the limit of detection of the measurement method would determine prevalence. While this may appear at face value, a sensible approach it results in estimates of any exposure to the agent rather than exposure sufficient to cause disease. In addition, published measurement studies are unlikely to be representative of all workers within the broad sectors of industry for which prevalence is estimated. In our opinion, this is inconsistent with the epidemiological risk estimates used and leads to highly inflated exposure prevalence estimates. We suggested that in order to arrive at more accurate estimates of the burden of occupational respiratory disease, it would be better to rely on validated Job-Exposure Matrices, such as SYNJEM (Peters et al. 2016). The WHO/ILO group has not yet produced estimates for the occupational lung fibrotic diseases. However, the WHO/ILO group has produced estimates for global deaths from COPD from occupational exposure to particulate matter, gases, and fumes—often referred to as vapours, gas, dust, or fumes (VGDF) (450,381 deaths in 2016; PAF 14.9%) (Pega et al. 2022). The estimate is similar to that from the GBD group (460,080 deaths in 2016 for COPD from particulate matter, gases and fumes combined with exposure to second-hand cigarette smoke at work; PAF 16.9%), which is perhaps unsurprising since they are both based on the same PAF data. These PAF data are comparable to data from an authoritative review that reported a pooled estimate of the occupational PAF of 14% for COPD from occupational exposure to VGDF (Blanc et al. 2019). The main difficulty with these estimates of occupational COPD mortality is the vague nature of the exposure measure and the uncertainty about how to action any intervention to reduce the risks. The exposure definition essentially encompasses most hazardous substances found at work.

How should researchers verify the reliability of their occupational disease burden estimates?

We have concerns about the reliability of the data for the NMSC estimates from UV exposure and the data that the WHO/ILO group will produce for crystalline silica, asbestos and coal dust, and fibrotic disease. The result in both instances is a likely overestimation of the number of cases of disease caused by workplace exposures. We have concerns about the use of non-specific exposure metrics when estimating burden because of the problem in identifying the appropriate strategies to control the risks. Our concerns are not unique; Coggon (2022) raised similar concerns, including the difficulty in identifying exposure and disease pairs where there is enough confidence that the association is causal and the challenges in characterizing exposure prevalence and duration and intensity of these exposures.

We completely accept that it is difficult to integrate the available data to estimate occupational disease burden, but it is important that everyone is assured of the validity of any estimates and that sources of bias are minimized. The methods should consider all sources of exposure data, including non-peer-reviewed data from regulators, employers, unions, and national and international statistics, and use strategies that allow integration of these diverse data sources, i.e. triangulation of the information. To this end, we propose several actions that researchers should complete and report along with their data.

1. Proactively engage in discussions with the wider academic community at an early stage of planning the research;
2. Get robust in-depth peer review of the proposed methodology prior to embarking on the work;
3. Identify appropriate causal pairs of exposure-disease where the exposure metric is specific and actionable;
4. Harmonize on investigating hazardous agents that are probable causes of diseases concerned, not where causation is unequivocal, and identifying the uncertainty of the evidence in presenting the results;
5. Justify the relevance of input data in terms of matching, e.g. prevalence and exposure duration and intensity data should match those of epidemiological studies from which the risk estimates are derived;
6. "Sense-check" specific input and output data with local experts to help ensure it is consistent with knowledge, e.g. is the exposure prevalence in line with what is known at regional and national level;
7. Consider alternative causes for the diseases being investigated and whether the occupational attributable fraction is consistent with what is known about the burden from these alternate causes. Provide justification in terms of the proportion of disease assigned to an agent, e.g. NMSC is mostly caused by solar UV, so an independent assessment of recreational burden should be consistent with the occupational burden;
8. Compare with and discuss other (national) burden estimates to assess how well the chosen approach fits existing evidence.

The WHO/ILO effort to estimate the number of deaths and the loss of health, as disability-adjusted life years, caused by a wide range of occupational risk factors is of great importance. Unfortunately, we believe that the methods chosen, the lack of scientific rigor, and the discourse have resulted in unreliable numbers, with likely overestimation of the burden. We need reliable information that helps efforts to prevent ill health and death from occupational exposures.

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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

No data were used in this study.

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