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The future excess fraction of occupational cancer among those exposed to carcinogens at work in Australia in 2012

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ABSTRACT

Background: Studies in other countries have generally found approximately 4% of current cancers to be attributable to past occupational exposures. This study aimed to estimate the future burden of cancer resulting from current occupational exposures in Australia.
Methods: The future excess fraction method was used to estimate the future burden of occupational cancer (2012–2094) among the proportion of the Australian working population who were exposed to occupational carcinogens in 2012. Calculations were conducted for 19 cancer types and 53 cancer-exposure pairings, assuming historical trends and current patterns continued to 2094.
Results: The cohort of 14.6 million Australians of working age in 2012 will develop an estimated 4.8 million cancers during their lifetime, of which 68,500 (1.4%) are attributable to occupational exposure in those exposed in 2012. The majority of these will be lung cancers (n = 26,000), leukaemias (n = 8000), and malignant mesotheliomas (n = 7500).
Conclusions: A significant proportion of future cancers will result from occupational exposures. This estimate is lower than previous estimates in the literature; however, our estimate is not directly comparable to past estimates of the occupational cancer burden because they describe different quantities – future cancers in currently exposed versus current cancers due to past exposures. The results of this study allow us to determine which current occupational exposures are most important, and where to target exposure prevention.

1. Introduction

Cancer represents a significant public health concern, accounting for approximately 19% of the total disease burden in Australia in 2012 [1]. Fortunately, cancer is largely preventable, with the majority of causal factors being environmental [2]. An important subset of preventable cancers is occupational cancers, in which the exposures are encountered involuntarily and often unknowingly, and in most cases there are obvious means of exposure reduction or prevention. Cancers commonly linked with occupation include cancers of the lung and pleura, bladder, and sinonasal cavity.

Approximately 3.6 million Australian workers were estimated to be exposed to occupational carcinogens in their current job in 2012 [3]. This represented nearly 40% of the Australian workforce. Estimating the burden of cancer resulting from these occupational exposures is a useful tool for policy planning and the prioritisation of potential intervention and control measures to prevent or reduce exposure at work.

The most common approach to calculating the burden of occupational cancer is the attributable risk approach, which

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estimates the proportion of cancer cases in a single year which are attributable to exposures occurring in the past [4]. The most widely cited paper to use this approach estimated that 4% of all cancer deaths in the United States occurring in 1978 were attributable to occupation [5]. Other attributable risk estimates of occupationally-related cancers have included a New Zealand study (1.8–4.2% of cases annually) [6], a more comprehensive study in the United Kingdom (4% of cases in 2005) [7,8], and mortality studies in the United States (2.4–4.8% of 1997 cancer deaths) [9] and Finland (8% of cancer deaths in 1996) [10]. In Australia, a 2006 estimate suggested that approximately 5000 cancers per year (11% in males and 2% in females) were attributed to occupational exposures [11]. However, the prevalence of exposure used in the latter study was based on Finnish exposure data from the 1950s and was criticised as being inappropriate for Australian conditions [12].

An alternative approach to calculating the burden of occupational cancer is the future excess fraction (FEF) method, which estimates the excess number of exposure-related cancers occurring over a number of years in the future among the proportion of the population exposed in a specific year [13]. This approach is useful when current exposure prevalence data are available, because data do not need to be extrapolated over time and no assumptions about cancer latency need be made.

The decision to use the attributable risk or FEF method in a particular study is dependent upon the aim of that study and the type of data available. The attributable risk method is used to answer the question of how many occupational cancers now and in the future result from past exposures, whereas the FEF method is appropriate for the question of how many people who are exposed now will develop cancer in the future. The FEF method may therefore be particularly useful for policy planning as it can show how many cancers will occur in the future in a currently exposed population under various exposure scenarios.

The aim of the current study was to use the FEF method to estimate the future burden of occupational cancer in Australia among those occupationally exposed to carcinogens in 2012.

2. Methods

The FEF method was used to estimate the future burden of occupational cancer among the Australian working age population who were exposed to carcinogens at work in 2012. We included 38 carcinogens prioritised on the basis of their evidence of carcinogenicity to humans (Group 1 or 2A) according to the International Agency for Research on Cancer (IARC) as at July 2011 and which were used in Australian workplaces [14]. The list of carcinogens by cancer site published on the IARC website [15] was consulted to identify the cancer sites associated with each of these 38 carcinogens. All cancer-carcinogen combinations listed with sufficient or limited evidence were included in the calculations. We did not include exposure circumstances (e.g. aluminium production, rubber manufacturing) or occupations (e.g. painter) listed by IARC as these were likely to overlap with the exposure to specific agents already considered, and in addition these circumstances may not be appropriate for exposure prevention and control policies due to their broad scope [14]. In total, calculations were conducted for 19 different cancer types and 53 cancer-carcinogen combinations.

Non-melanoma skin cancers were excluded from these calculations as comprehensive incidence data by year and sex are not available for non-melanoma skin cancer in Australia [16].

2.1. Data sources

The cohort for this study was defined as Australian residents aged between 18 and 65 in 2012 (i.e. the Australian working age population in 2012). A matrix showing the proportionate survival of an individual at each future age (until the year 2094) was first calculated using a double decrement life-table to adjust for competing causes of mortality, whereby the two endpoints were death and first diagnosis of the cancer of interest (such that an individual no longer contributed person-years after they either died or were diagnosed with the cancer of interest, whichever occurred first). This matrix was then multiplied by the 2012 mid-year population statistics obtained from the Australian Bureau of Statistics (ABS) [17] to obtain the future person-years-at-risk for the cohort until 2094. Matrices were calculated separately by cancer type and sex, such that 37 such matrices were created (18 cancer types for male and female, plus ovarian for female only).

Information concerning the prevalence of exposure to carcinogens at work in 2012 was obtained from our previous Australian Work Exposures Study (AWES) [3], supplemented by the Australian Work Exposures Study-Western Australia. AWES was a cross-sectional telephone survey of 4993 Australian workers aged 18–65, supplemented by an additional 505 workers from the state of Western Australia. This study achieved a response fraction of 53% and cooperation fraction of 72%. Full methods have been described previously [3]. These data provided an estimate of exposure prevalence for each of the 38 carcinogens, generated separately by sex and occupational group. Information about the qualitative level of exposure was included, enabling the exposed population to be divided into a 'low' exposure group (those assessed as having a 'low' or 'medium' level of exposure to the carcinogen of interest) and a 'high' exposure group (those assessed as having a 'high' level of exposure to the carcinogen of interest).

Relative risk estimates for high and low exposures for each of the 53 cancer-carcinogen combinations were sought from the literature (see Supplementary Table S1). In the majority of cases, the relative risks selected by Rushton and colleagues [7] were considered appropriate for our study as they were derived from meta-analyses and/or were based on relevant exposures. Where these were unsuitable for Australian circumstances (e.g. melanoma and solar radiation exposure), a literature review was conducted. Preference was given to risk estimates derived from meta-analyses, followed by key studies in the area. Where no relative risk estimate for low exposure was available, and where it seemed the effect would not be strong, no excess risk was assumed (i.e. relative risk of 1.0).

To estimate the number of cancers occurring in the future to 2094, we used the R-based software 'Canproj' [18], which uses a decision tree to determine and conduct the most appropriate projection model based on past (observed) cancer registrations, choosing between an age-period-cohort or loglinear regression model. Three inputs were required: the number of observed cancer registrations over a period of time; the observed population over the same period; and the projected population. The number of observed cancer registrations by site, sex, five-year age group, and year of diagnosis were obtained from the Australian Institute of Health and Welfare [19] from 1986 to 2010. Australian population numbers by sex and five-year age group for the same period [17] as well as inter-Census extrapolations and population projections by sex and single year of age for 2011–2094 [20] were obtained from the ABS. A limitation of Canproj is that only 25 years can be projected using the current program. We needed to project to 2094, so future projections after 2035 used the initial projected incidence rates and the relevant periods of observed incidence (1986–2010) to produce a new prediction base.

As the accuracy of this approach is unknown, we also conducted a sensitivity analysis using cancer incidence rates projected on the basis of demographic change only (see Supplementary Methods).

Projected cancer incidence was estimated to 2094 as this was the year in which the youngest members of the cohort (those aged