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Impact of work-related cancers in Taiwan—Estimation with QALY (quality-adjusted life year) and healthcare costs

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ABSTRACT

This study estimates the annual numbers of eight work-related cancers, total losses of quality-adjusted life years (QALYs), and lifetime healthcare expenditures that possibly could be saved by improving occupational health in Taiwan. Three databases were interlinked: the Taiwan Cancer Registry, the National Mortality Registry, and the National Health Insurance Research Database. Annual numbers of work-related cancers were estimated based on attributable fractions (AFs) abstracted from a literature review. The survival functions for eight cancers were estimated and extrapolated to lifetime using a semi-parametric method. A convenience sample of 8846 measurements of patients' quality of life with EQ-5D was collected for utility values and multiplied by survival functions to estimate quality-adjusted life expectancies (QALEs). The loss-of-QALE was obtained by subtracting the QALE of cancer from age- and sex-matched referents simulated from national vital statistics. The lifetime healthcare expenditures were estimated by multiplying the survival probability with mean monthly costs paid by the National Health Insurance for cancer diagnosis and treatment and summing this for the expected lifetime. A total of 3010 males and 726 females with eight work-related cancers were estimated in 2010. Among them, lung cancer ranked first in terms of QALY loss, with an annual total loss-of-QALE of 28,463 QALYs and total lifetime healthcare expenditures of US$36.6 million. Successful prevention of eight work-related cancers would not only avoid the occurrence of 3736 cases of cancer, but would also save more than US$70 million in healthcare costs and 46,750 QALYs for the Taiwan society in 2010.

1. Introduction

Cancer is one of the leading issues in global health due to its substantial reduction of life expectancy as well as quality of life (QOL). The financial burden associated with healthcare expenditures on cancer can have a massive impact on patients, their families, and the whole of society. Recently, the Global Burden of Disease Study has provided global and regional estimates of disability-adjusted life years (DALYs) lost due to many risk factors, including asbestos and other occupational exposures (Lozano et al., 2012). A study by the World Health Organization (WHO) estimated that approximately one fifth of all cancer cases could be attributed to occupations, and that these cases resulted in 1.3 million deaths each year worldwide (Prüss-Üstün et al., 2006). Over the past four decades, the International Agency for Research on Cancer (IARC) has also documented the workplace as a major source of exposure by having evaluated over 900 potential carcinogens (International Agency for Research on Cancer, World Health Organization). These estimates imply that a substantial proportion of incidences of cancer could possibly be prevented in work-related circumstances. However, practical recognition of cancer patients with occupational attribution for appropriate compensation remains a very challenging task (Langård and Lee, 2011) for several reasons. First, the long latency from exposure to diagnosis makes it difficult to identify a causal relationship (Baxter and Hunter, 2010). Second, it has been

Abbreviations: AF, Attributable fraction; CAREX, CARcinogen EXposure; DALY, Disability-adjusted life year; IARC, International Agency for Research on Cancer; LTHE, Lifetime healthcare expenditure; NHI, National Health Insurance; NHIRD, National Health Insurance Research Database; NMR, National Mortality Registry; QALE, Quality-adjusted life expectancy; QALY, Quality-adjusted life year; QOL, Quality of life; TCR, Taiwan Cancer Registry; WHO, World Health Organization.

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difficult to demonstrate the intensity and duration of exposure or dose of exposure to carcinogens, as there were generally few measurements at the beginning of industrialization because of a lack of knowledge and technology (World Health Organization, 1994). Third, the current theory of carcinogenesis is inclined to view cancer as a multistep process. Moreover, genetic factors and personal behaviors, including cigarette smoking, may contribute synergistically to the occurrence of work-related cancer (Erren et al., 1999; European Commission, 2009).

In order to promote recognition of occupational cancer, estimates have been made of the proportion of cancers attributable to occupational exposure in both developed and developing countries (Parkin, 2011; Nurminen and Karjalainen, 2001; Mosavi-Jarrahi et al., 2009). To provoke policy consideration and improvements, however, we need to apply a common unit of measurement of outcomes and potential benefits of prevention, of which savings from expected years of life loss (EYLL) and lifetime healthcare expenditures (LTHE) have been proposed for the purpose of comparison of the impacts of work-related cancers (U.S. Environmental Protection Agency, 1997). However, it would be directly comparable with clinical healthcare technologies if the burden of work-related cancer could be measured with quality-adjusted life year (QALY) (Weinstein et al., 2009; Lipscomb et al., 2009; Kind et al., 2009), which could be estimated from the loss of quality-adjusted life expectancy (QALE) for different sites of cancer. In this study, we selected eight work-related cancers because of their high prevalence in Taiwan, which would be an initial step to estimate impacts from work-related cancers.

In Taiwan, there were a total of 463,703 overall cancer patients diagnosed in 2010; cancer related expenses accounted for 10.2% of the total National Health Insurance (NHI) healthcare expenditures that year (Bureau of Health Promotion Administration, Ministry of Health and Welfare in Taiwan; National Health Insurance Administration, Ministry of Health and Welfare in Taiwan, 2010). Unfortunately, the labor insurance system's compensation rate for occupational cancer is extremely low, with annual numbers ranging between 0 and 13 during 2003–2012 (Ministry of Labor in Taiwan). In this study, we aimed to estimate the annual numbers of work-related cancers, total losses of quality-adjusted life years (QALYs), and lifetime healthcare expenditures that potentially could be saved by improving occupational health in Taiwan.

2. Materials and methods

Before its commencement, this study was approved by the Institutional Review Board (IRB) of National Cheng Kung University Hospital (NCKUH) (B-ER-102-162). All patients with QOL data also provided signed informed consent. In brief, we first obtained the AFs of 8 work-related cancers based on Nurminen and Karjalainen's estimates (Nurminen and Karjalainen, 2001), which were followed by multiplying the above figures with the annual total numbers, loss-of-QALEs, and financial burdens for different cancers based on empirical data of Taiwan. Linkages of the Taiwan Cancer Registry (TCR), the National Mortality Registry (NMR), and the National Health Insurance Research Database (NHIRD) were performed to ascertain if a person is deceased, which were used to construct the lifetime survival functions of cancers for different organ-systems. As the NMR has been very comprehensive and all types of cancer are fully covered by the National Health Insurance with no copayment, the rates of loss to follow-up would be minimal or approaching 0. The QOL data were collected from patients who were treated in the Department of Oncology, NCKUH, and then were adjusted with survival function and summed up throughout lifetime to estimate QALE. We also adopted the method proposed by the World Health Organization (2004) to estimate the number of work-related lung cancer cases for validation.

2.1. Estimation of incidences of work-related cancers in Taiwan in 2010

The AFs of cancers caused by occupational exposure were taken directly from the comprehensive literature review conducted by Nurminen and Karjalainen, which summarized the most valid and/or suitable estimated relative risks for each cancer/substance combination (Nurminen and Karjalainen, 2001). The risk factors considered in this study for the 8 work-related cancers were based on literature review and listed as follows: polycyclic aromatic hydrocarbons, hydrocarbon solvents for cancer of oral cavity or cancer of esophagus, 8 lung carcinogens (arsenic, asbestos, beryllium, cadmium, chromium, diesel exhaust, nickel, and silica) for lung cancer, farming and rearing of livestock for stomach cancer, aflatoxins, chlorinated hydrocarbon solvents for liver cancer, asbestos, polycyclic aromatic hydrocarbons and other combustion products for colorectal cancer, ionizing radiation for breast cancer, and aromatic hydrocarbon solvents for cervical cancer.

Lung, colorectal, and liver cancers are leading causes of mortality in both genders, as well as breast and cervical cancers in females in Taiwan (Bureau of Health Promotion Administration, Ministry of Health and Welfare in Taiwan). Asbestos, a well-known occupational carcinogen, classified as IARC group I, is associated with increased risk of lung, oral, esophageal, stomach, and colorectal cancers (International Agency for Research on Cancer, World Health Organization; Clin et al., 2009; Kjaerheim et al., 2005; Strand et al., 2010; Pukkala et al., 2009). Liver cancer is causally linked to occupational exposure to vinyl chloride (Ward et al., 2001) and hepatitis C (Yazdanpanah et al., 2005). Breast cancer has been recognized as a compensable occupational disease due to long-term shift work, as shown by epidemiological studies on nurses (Bonde et al., 2012). Cervical cancer may be associated with exposure to some hydrocarbon solvents (Weiderpass et al., 2001). We selected the eight cancers based on disease prevalence in Taiwan and the availability of data on quality of life.

We further obtained the numbers of incident cases of oral, esophageal, lung, stomach, colorectal, and liver cancers, as well as female cancers of breast and cervix, from the 2010 Annual Report of the Taiwan Cancer Registry (Bureau of Health Promotion Administration, Ministry of Health and Welfare in Taiwan), which were multiplied with the AFs to estimate the numbers of possible work-related cancers.

2.2. Estimation of total expected loss-of-QALE and healthcare expenditures

2.2.1. Study population and dataset

A total of 395,330 patients of the 8 work-related cancers who received care under the National Health Insurance (NHI) system during the period from 1998 to 2007, with pathologically verified cancers registered in the TCR were included and linked with the NMR until the end of 2010 to determine their vital status. They were then linked to the NHIRD to obtain reimbursement data. Then the identification number was encrypted before use for further analysis. The file contained detailed demographic data (including birthdate and gender), along with information regarding all payments and health care services provided for each patient. The data of diagnoses were coded according to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). The eight sites of cancer included oral cavity (ICD-9-CM code: 140-141), esophagus (ICD-9-CM code: 150), lung (ICD-9-CM code: 162), stomach (ICD-9-CM code: 151), liver (ICD-9-CM code: 155), colorectum (ICD-9-CM code: 153-154), and female cancers of breast (ICD-9-CM code: 174) and cervix (ICD-9-CM code: 180).

2.3. Estimation of life expectancy according to survival analysis and extrapolation

A semiparametric method was applied to extrapolate survival for up to 50 years to derive the lifetime survival function after the diagnosis of each cancer. Briefly, Kaplan–Meier's was first conducted for