Preventive Medicine Reports 11 (2018) 125–130

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Estimating lifetime and 10-year risk of lung cancer☆

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ARTICLE INFO

Keywords:
Lung cancer
Risk communication
Lifetime risk
Public health indicator
Switzerland

ABSTRACT

Lung cancer is the commonest cancer worldwide. Mortality and incidence rates are traditionally used to assess cancer burden and as public health indicators. However, these metrics are difficult to interpret at an individual level. Providing the lifetime and 10-year risks of cancer could improve risk communication. Our aim was to estimate current lifetime and 10-year risks of lung cancer by smoking status and changes in these risks between 1995 and 2013 in a Swiss population. We used all lung cancer cases recorded between 1995 and 2013 by two population-based cancer registries in the contiguous cantons of Vaud and Valais, in Western Switzerland. We estimated sex-specific lifetime risk and 10-year risk of lung cancer using the current probability method, accounting for competing risk of death. Estimates were also provided by smoking status. Between 1995 and 2013, 9623 cases of lung cancer were recorded. During this period, the lifetime risk decreased in men from 7.1% to 6.7% and increased in women from 2.5% to 4.1%. In both sexes, the 10-year risk of lung cancer increased with age until the age of 60–70 and decreased thereafter. Difference in the cumulative risk between current, former, and never smokers were very large and reported in user-friendly charts to ease risk communication. These lifetime and 10-year risk estimates could be used systematically as public health indicators. Regularly updating risk estimations are necessary for conditions like lung cancer whose incidence has changed substantially.

1. Introduction

In 2012, lung cancer was the commonest diagnosed cancer in men worldwide and the third most frequently diagnosed cancer in women, after breast and colorectal cancer (Torre et al., 2015). In Switzerland, between 2008 and 2012, it was the leading cause of cancer death in men and the second cause of cancer death in women, after breast cancer (Arndt et al., 2016). Because smoking is the major cause of lung cancer (Janssen-Heijnen and Coebergh, 2001), trends in lung cancer incidence are closely following trends in smoking habits in the population, with a latency time of about 30 years (Oberli et al., 2016). In Switzerland, smoking prevalence peaked in the 1950s in men and in the 1970s among women (Oberli et al., 2016). Hence, lung cancer incidence reached in men a peak in the 1980s and decreased thereafter (Janssen-Heijnen and Coebergh, 2003; Levi et al., 1997). Among women, the incidence has increased at least since the 1970s (Levi et al., 1997) and, apparently, has not reached a peak yet (Rapiti et al., 2014).

Because cancers are feared diseases, an adequate risk communication about the individual chance of developing cancer is important (Schwartz et al., 1999; Gigerenzer et al., 2010; Kurz-Milcke et al., 2008). To assess the burden of cancer, mortality and incidence are frequently used. They are also standard public health indicators. However, these epidemiological and population level metrics are not simple to use for risk communication. Indeed, it might be difficult for lay persons to grasp one's own risk of having e.g. a lung cancer through age-standardized or crude rates of incidence or mortality (Sasieni and Adams, 1999). To improve health risk communication, we can estimate the lifetime risk, which is the cumulative risk of being affected by a disease during the existence (Germann et al., 2016). Lifetime risk appears to be an informative and easily understood measure of the risk of disease in individuals (Narayan et al., 2003). As many people are interested in their own risk of disease in the near future (Woloshin et al., 2008a), the cumulative 10-year risk, i.e. the probability, in percentage, for a given individual of developing lung cancer in the next 10 years, could be another interesting metric to help patients and health professionals for health decision making (screening or change in health

☆ No disclaimer

No specific funding: This research did not necessitate any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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https://doi.org/10.1016/j.pmedr.2018.06.010
Received 26 November 2017; Received in revised form 11 June 2018; Accepted 14 June 2018
Available online 18 June 2018

behavior) and to facilitate the discussions about cancer risk. Importantly, these risks have to be regularly updated, following changing incidence across time.

The lifetime risk of cancer has been estimated and is publicly available in several countries, such as Canada or the United States. To our knowledge, the 10-years cumulative risk is not systematically computed by any country worldwide. Our goal was therefore to estimate the sex-specific lifetime risk and 10-year risk of lung cancer in a Swiss population, by smoking status, and assess changes in these risks between 1995 and 2013. Further, we provided sex-specific user-friendly tables and graphical tools for risk communication about lung cancer.

2. Material and methods

2.1. Study design

We conducted a population-based temporal trend study of the risk of lung cancer in two regions of Western Switzerland (cantons of Vaud and Valais) between 1995 and 2013. The total number of inhabitants in the cantons of Vaud and Valais is 1,123,998 corresponding to 13% of the total population of Switzerland.

2.2. Data source

In Switzerland, data on all new cancer cases are collected, documented and recorded by population-based regional cancer registries. The National Institute for Cancer Epidemiology and Registration (NICER) compiles and aggregates this data (www.nicer.org). Quality control procedures are based on the guidelines from the European Network of Cancer Registries (Working Group of the International Association of Cancer R, 2005). Variables routinely harvested by Swiss cancer registries include notably the birth date, sex, status at last follow-up (alive, dead or left canton) and date of last follow-up of the patient, as well as for each tumor its date of diagnosis (termed date of incidence), localization, histological type, malignancy, stage TNM and size.

We used data from the Vaud Cancer Registry (Registre Vaudois des tumeurs; RVT) at the Institut Universitaire de Médecine Sociale et Préventive (IUMSP; www.iumsp.ch) and the Valais Cancer Registry (Registre Valaisan des tumeurs; RVsT) at the Observatoire Valaisan de la Santé (OVS; www.ovs.ch). These registries collect data on all new (incident) cases of cancer diagnosed in the cantons of Vaud and Valais, since 1974 and 1989 respectively. Data on all cases of lung cancer recorded between 1995 and 2013 were used for this study. A recent evaluation of the completeness of cancer case ascertainment in Switzerland, including the Vaud and Valais Cancer Registries, indicated a high completeness for most cancer types, including lung cancer (Lorez et al., 2017). Annual mortality records were provided by the Federal Statistical Office. Death rates of lung cancer were extracted from these records. Information on smoking prevalence were obtained through Suchmonitoring Schweiz (www.suchtmonitoring.ch).

2.3. Statistical analyzes

We analyzed trend data across 4 time periods, i.e., 1995–1998, 1999–2003, 2004–2008, and 2009–2013. Annual lung cancer incidence and mortality rates, stratified by sex, were computed. Rates were age-standardized to the European standard population (Curtin and Klein, 1995).

The current probability method was used to estimate the lifetime risk (Sasieni et al., 2011). This method allows the estimation of cumulative risk of any condition throughout lifetime, using the population current incidence and mortality at each age. It accounts for the risk of being affected for the first time by the condition at each age, and for the competitive risk of dying (and not reaching that age) (Germann et al., 2016; Sasieni et al., 2011). With data containing only primary tumors, the current probability method is considered as the "gold standard" to estimate the lifetime risk of any conditions during a given span of life (Sasieni et al., 2011). To use this method, we estimated the number of first cancer cases and the number of cancer-free individuals (by definition, not recorded in cancer registries). We also estimated the rates of cancer (incidence) and of all-cause mortality (Ahmad et al., 2015). We assumed that, within each time period considered, the incidence and mortality rates of lung cancer were constant over time for each 5-year age group. For each year of life, we calculated the risk (in %) of lung cancer. The cumulative lifetime risk (in %) was computed for men and women and for each time-period by the sum of these risks over the lifespan.

We created a 10-year lung cancer cumulative risk table and chart, inspired by Woloshin et al. (Woloshin et al., 2008b). To estimate the 10-year cumulative risk of lung cancer at age A, we computed the difference between the cumulative risk until age A + 10 years and the cumulative risk until age A. For example, the cumulative 10-year risk since the age of 40 years old (that is, between the age of 40 and 49) is the difference between the cumulative risk of having a lung cancer at age 50 minus the cumulative risk at age 40. The 10-year risk was estimated at age 20, 30, 40, 50, 60, 70, 80, and 90. Since the risk of lung cancer differs by sex, we built separate tables and charts for men and women.

We estimated the lifetime and 10-year risks by smoking status indirectly (Woloshin et al., 2008b; Becher et al., 2018). First, we used the sex-, age- and time-period specific prevalence of smoking in Switzerland (Supplemental Table S1). Second, we used the relative risk (RR) of lung cancer associated with current and former smoking compared to never smoking, derived from a recent systematic review (Lee et al., 2012) (i.e., RR = 6.57 for current smokers below 60 years of age, 9.62 for current smokers between 60 and 69, 9.07 for current smokers 70 years old or more, and 4.30 for former smokers of all ages). For each year of life, we calculated the risk (in %) of lung cancer by smoking status with the following formulas:

- $$\begin{aligned}\text{Risk}_{\text{never smokers}} = \text{risk}_{\text{whole population}}/(&\text{Prevalence}_{\text{never smokers}} \\ &+ \text{Prevalence}_{\text{current smokers}} \times \text{RR}_{\text{current smokers}} \\ &+ \text{Prevalence}_{\text{former smokers}} \times \text{RR}_{\text{former smokers}})\end{aligned}$$
- $$\text{Risk}_{\text{current smokers}} = \text{risk}_{\text{never smokers}} \times \text{RR}_{\text{current smokers}}$$
- $$\text{Risk}_{\text{former smokers}} = \text{risk}_{\text{never smokers}} \times \text{RR}_{\text{former smokers}}$$

The cumulative lifetime and 10-year risks were computed for current, former, and never smokers by the sum of these risks over specific lifespans.

2.4. Ethics

Anonymous health related personal data with no possibility to identify individuals and recorded by cancer registries for research activities were used. There was no threat to patient confidentiality. According to the Swiss Human Research Act (Humanforschungsgesetz HFG), no ethical approval was needed for such analyses.

3. Results

Between 1995 and 2013, 9623 lung cancer cases were diagnosed in