Preventive Medicine 57 (2013) 634–640

Contents lists available at ScienceDirect

Preventive Medicine

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

Smoking prevalence and its impacts on lung cancer mortality in Sub-Saharan Africa: An epidemiological study ☆

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ARTICLE INFO

Available online 5 September 2013

Keywords:
Mortality
Lung cancer
Epidemiologic model
Smoking prevalence
Africa

ABSTRACT

Background. Reliable mortality data are sparse for developing countries. Furthermore, risk factor prevalence information is hardly available and thus not taken into consideration when estimating mortality.

Methods. The authors used a validated, statistical model combined with representative smoking prevalence from WHO STEPS surveys to estimate lung cancer mortality for six Sub-Saharan African countries (Benin, Malawi, Mozambique, Niger, Sierra Leone, Swaziland). Results were compared to a reference database (GLOBOCAN). Using different smoking prevalence scenarios, future lung cancer deaths were estimated.

Results. The prevalence of current moderate smoking among males ranged from 8.7% to 34.6%. Prevalence was much lower among females. For all countries considered, our mortality estimates were higher than GLOBOCAN estimates that do not consider prevalence: Overall, we estimated 2405 lung cancer deaths for 2008 compared to 531 deaths estimated by GLOBOCAN. Up to 2030, lung cancer deaths are expected to increase in general and by over 100% in Benin and Niger. Even under the assumption of decrease in smoking prevalence, lung cancer mortality will rise.

Conclusion. On the bases of detailed smoking prevalence information, our findings implicate a higher lung cancer burden in low income countries. The epidemiologic transition in African low-income countries alludes to the need for targeted health prevention efforts.

Introduction

Tobacco use is the world's leading risk factor for cancer mortality and 71% of global lung cancer deaths are attributable to smoking. Tobacco smoking has a definitive effect in different cancer-sites with the relative risks (RRs) being highest for lung cancer and laryngeal cancer (IARC, 2004; Kuper et al., 2002).

Taking into consideration latency periods for smoking and cancer recent increases in tobacco consumption heavily influence future disease burden (Doll et al., 2004). However, reliable mortality projections are lacking, particularly for African countries that face largest increases in smoking prevalence (Jha et al., 2002). Methods previously applied to project lung cancer burden primarily rely on population projection (Smith et al., 2009; Yabroff et al., 2008) or regression models (French et al., 2006; Yang et al., 2005) that take into consideration demographic changes and age-specific rates. By assuming a stable age-pattern of new cases, most of these models do not reflect differential rates of increase in lung cancer in different age-groups, as indicated earlier (Murray and Lopez, 1997). Bayesian approaches of the age–period–cohort models have also been used (Brennan and Bray, 2002; Knorr-Held and Rainer, 2001; Negri et al., 1990) to project lung cancer mortality. Some of them included information on tobacco consumption from developed countries (Brown and Kessler, 1988). Other projections of mortality took independent variables including socio-economic status and smoking intensity into consideration (Murray and Lopez, 1997).

All these methods rely on lung cancer mortality data from past decades, which are not available for Sub-Saharan Africa.

The main public databases for cancer mortality, the GLOBOCAN, released by the International Agency for Research on Cancer (IARC) (Ferlay et al., 2010) and the WHO Mortality Database (WHO, 2008a) have so far not used smoking-exposure information for generating their estimates. GLOBOCAN data rely on trends observed in cancer incidence in particular countries and are based on 26 different approaches for different groups of countries. Survival statistics are used to estimate mortality from the incidence data only.

Building on the previously developed model which uses smoking prevalence information (Winkler et al., 2011) we estimate lung cancer death and age-standardized mortality for six Sub-Saharan African countries. Country-specific data on tobacco smoking determining lung cancer risk (Zaridze and Peto, 1986) are taken into consideration and were obtained from the WHO STEPS surveillance system (WHO,

Abbreviations: LMICs, low and middle income countries; IARC, International Agency for Research on Cancer; ASR, age-standardized rate; RR, relative risk.

☆ All countries used the same paper-based and interviewer-led questionnaire.

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0091-7435/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.ypmed.2013.08.022

2008b). Findings are compared to mortality estimates from GLOBOCAN (Ferlay et al., 2010) and sensitivity analyses are applied. We also project lung cancer deaths in Sub-Saharan African countries up to 2030.

Methods

Data sources

Six Sub-Saharan African countries (Benin, Malawi, Mozambique, Niger, Sierra Leone, Swaziland) conducted nationally representative STEPS surveys (2003–2009) that include standardized questions on smoking behavior, smoking history including time since quitting smoking, and past and present smoking experience by dose and duration. All countries used the same paper-based and interviewer-led questionnaire. Country-specific characteristics of the survey are shown in Table 1.

Prior to categorizing data from STEPS surveys into smoking categories, 1136 (4.6%) individual records were dropped due to any of the following reasons: missing sex or age; age less than 25 years (due to low lung cancer mortality in this age-group); and non-response to questions on smoking. From a total of 24,909 the remaining 23,773 participants were categorized into non-smoker (1), ex-smoker (2), non-daily smoker (3) and current smoker (4). Details on categories are found in Table 2.

Dose groups and corresponding RRs were obtained from previous studies and are presented in Table 3. Detailed information can be found elsewhere (Winkler et al., 2011).

For 122 of the 849 participants who had smoked daily in the past, age of quitting smoking was missing. Age of quitting was estimated using the average age of quitting from other participants of the same sex, age-group and country. Of 3106 current smokers, 818 were missing age at which they started smoking and 528 were missing smoking dose. These missing data were estimated using averages from other current smokers of the same age–sex–country group. In a sensitivity analysis we assumed only half the estimated dose (past smoker) and starting to smoke age after 20 years of age (current smoker) for these individuals. For age-groups above 65 years, we assume prevalence is equal to the oldest age-group for which prevalence data are given (60–64 years).

The quantity of tobacco smoked daily was estimated for all ex-smokers using the average dose smoked per day by current smokers in their respective age–sex–country group.

Statistical analysis

Details on the statistical method to estimate lung cancer mortality related to smoking prevalence have been published elsewhere (Ng et al., 2009; Winkler et al., 2011).

In brief, age-specific lung cancer mortality rates λ_{jk} for country k were estimated according to Eq. (1) by combining lung cancer mortality in non-smokers λ_{j0} in age group j with country-specific smoking prevalence p_{jks} in dose group s, age group j and country k, and dose and age-specific relative risks RR_{js} associated with dose s. Data on age-specific lung cancer mortality in non-smokers were directly available from four epidemiologic studies (see Appendix A) (Ando et al., 2003; Thun et al., 2006; Wakelee et al., 2007; Winkler et al., 2006). These data were combined into a summary estimate for age-specific lung cancer rates in non-smokers (non-smoker mortality rate per 100,000 = $\log_{10}(\lambda_{j0}) = -16.07 - 0.041 \cdot \text{age} + 4.82 \cdot \ln(\text{age})$).

$$\lambda_{jk} = \sum_{s=0}^{s} \lambda_{j0} RR_s p_{jks} \tag{1}$$

Table 1
Characteristics of the STEPS survey by country collecting prevalence information.

Country name	Year	Scope	Age range	Survey sample size	Population size (thousands)	Records used
Benin	2008	National	25–64	6904	8935	6798
Malawi	2009	National	25–64	5524	15,263	5239
Mozambique	2005	National	25–64	3312	22,894	3296
Niger	2007	National	15–64	2849	15,290	2174
Sierra Leone	2009	National	25–64	5032	5696	4986
Swaziland	2007	National	25–64	1288	1185	1280

Table 2
Details of categories of smoking status.

Category	Characteristics
1—Non-smoker	Not smoking tobacco currently, not smoked daily in the past.
2—Ex-smoker	Not smoking tobacco currently.
	a. Smoked 10 or fewer pack-years daily in the past but stopped smoking daily more than 5 years ago.
	b. Smoked more than 10 pack-years daily in the past but stopped smoking daily more than 5 years ago.
3—Non-daily smoker	Smoking tobacco currently, not on a daily basis.
4—Current smoker	a. Smoking tobacco currently, on a daily basis.
	aa. Started smoking tobacco on a daily basis before the age of 20 years (less than 10 cigarettes per day, 10 to 19 cigarettes per day, 20 or more cigarettes per day)
	ab. Started smoking tobacco on a daily basis at the age of 20 years or older (less than 10 cigarettes per day, 10 to 19 cigarettes per day, 20 or more cigarettes per day)
	b. Not smoking tobacco currently on a daily basis but stopped smoking daily within the past 5 years.

Dose-specific RRs (Table 2) were estimated based on models derived from the American Cancer Society's Cancer Prevention Study I and other cohort studies. The absolute number of current and future lung cancer deaths D_k was estimated as $D_k = \sum_{j=1}^{14} \lambda_{jk} n_{jk}$. We included population figures and projects n_{jk} up to the year 2030 (UN, 2009) and calculated age-standardized mortality rates by assuming constant smoking prevalence (scenario 1). Further, we projected two additional smoking scenarios: Scenario 2 assumes a yearly increase in smoking prevalence resulting in a 50% increase in 2030. The increase is assumed to occur uniformly in all dose groups and both sexes. In contrast, scenario 3 assumes a 50% decrease in smoking prevalence. All calculations were done separately for each sex.

In order to evaluate the main assumptions of the modeling procedure, we performed a sensitivity analysis. Lower and upper limits were calculated to address the observed country-specific variation (a) in lung cancer mortality rates among non-smokers and (b) in RR for chronic diseases. Based on the observed variation of lung cancer mortality in non-smokers (Winkler et al., 2011), baseline mortality was multiplied by 0.5 for the lower limit of the sensitivity analysis and by 2 for the upper limit. Published variations of RRs were taken into account by the factor 0.8 for the lower limit and 1.25 for the upper limit (Yusuf et al., 2004).

Results

Smoking prevalence by dose category and age varied greatly between countries. *Current tobacco smoking*, in particular *heavy tobacco* smoking (≥10 cigs/d), was much more common in males than females and showed the highest prevalence in Sierra Leone of 14.3% in males and 1.4% in females. In Niger, heavy smoking was less common with no females and up to 2.2% of males. The share of *moderate current smokers* (<10 cigs/d) was higher with 34.6% of the male population in

Table 3
Smoking dose categories s and corresponding relative risks (in comparison to non-smokers).

Smoking dose s		RR		
Non-smokers or never smoked daily				1
≤10 pack-years in the past				3
>10 pack-years in the past				10
Non-daily smoker				1.5
		age <40	age 40–59	age ≥60
Started before age 20	<10 cigs/d	2.3	4.2	6.1
	10–19 cigs/d	4.5	8.2	11.9
	≥20 cigs/d	7.9	14.3	20.8
Started after age 20	<10 cigs/d	1.7	3.0	4.4
	10–19 cigs/d	3.2	5.8	8.5
	≥20 cigs/d	5.7	10.2	14.8