Original Investigation

Smoking Prevalence and Cigarette Consumption in 187 Countries, 1980-2012

Marie Ng, PhD; Michael K. Freeman, MPH; Thomas D. Fleming, BS; Margaret Robinson, BA; Laura Dwyer-Lindgren, MPH; Blake Thomson, BA; Alexandra Wollum, BA; Ella Sanman, BS; Sarah Wulf, MPH; Alan D. Lopez, PhD; Christopher J. L. Murray, MD, DPhil; Emmanuela Gakidou, PhD

IMPORTANCE Tobacco is a leading global disease risk factor. Understanding national trends in prevalence and consumption is critical for prioritizing action and evaluating tobacco control progress.

OBJECTIVE To estimate the prevalence of daily smoking by age and sex and the number of cigarettes per smoker per day for 187 countries from 1980 to 2012.

DESIGN Nationally representative sources that measured tobacco use (n = 2102 country-years of data) were systematically identified. Survey data that did not report daily tobacco smoking were adjusted using the average relationship between different definitions. Age-sex-country-year observations (n = 38 315) were synthesized using spatial-temporal gaussian process regression to model prevalence estimates by age, sex, country, and year. Data on consumption of cigarettes were used to generate estimates of cigarettes per smoker per day.

MAIN OUTCOMES AND MEASURES Modeled age-standardized prevalence of daily tobacco smoking by age, sex, country, and year; cigarettes per smoker per day by country and year.

RESULTS Global modeled age-standardized prevalence of daily tobacco smoking in the population older than 15 years decreased from 41.2% (95% uncertainty interval [UI], 40.0%-42.6%) in 1980 to 31.1% (95% UI, 30.2%-32.0%; $P < .001$) in 2012 for men and from 10.6% (95% UI, 10.2%-11.1%) to 6.2% (95% UI, 6.0%-6.4%; $P < .001$) for women. Global modeled prevalence declined at a faster rate from 1996 to 2006 (mean annualized rate of decline, 1.7%; 95% UI, 1.5%-1.9%) compared with the subsequent period (mean annualized rate of decline, 0.9%; 95% UI, 0.5%-1.3%; $P = .003$). Despite the decline in modeled prevalence, the number of daily smokers increased from 721 million (95% UI, 700 million–742 million) in 1980 to 967 million (95% UI, 944 million–989 million; $P < .001$) in 2012. Modeled prevalence rates exhibited substantial variation across age, sex, and countries, with rates below 5% for women in some African countries to more than 55% for men in Timor-Leste and Indonesia. The number of cigarettes per smoker per day also varied widely across countries and was not correlated with modeled prevalence.

CONCLUSIONS AND RELEVANCE Since 1980, large reductions in the estimated prevalence of daily smoking were observed at the global level for both men and women, but because of population growth, the number of smokers increased significantly. As tobacco remains a threat to the health of the world's population, intensified efforts to control its use are needed.

JAMA. 2014;311(2):183-192. doi:10.1001/jama.2013.284692

Interactive at jama.com

Supplemental content at jama.com

Author Affiliations: Institute for Health Metrics and Evaluation, University of Washington, Seattle (Ng, Freeman, Fleming, Robinson, Dwyer-Lindgren, Thomson, Wollum, Sanman, Wulf, Murray, Gakidou); School of Population and Global Health, University of Melbourne, Melbourne, Victoria, Australia (Lopez).

Corresponding Author: Christopher J. L. Murray, MD, DPhil, Institute for Health Metrics and Evaluation, University of Washington, 2301 Fifth Ave, Ste 600, Seattle, WA 98121 (cjlm@uw.edu).

The year 2014 marks the 50th anniversary of the release of the first US surgeon general's report[1] on the health effects of smoking. The report's conclusions led to further research on both the consequences of tobacco use and potential interventions to reduce tobacco prevalence and cigarette consumption. A wide range of effective interventions are available including increasing prices and bans on advertising, promotion, sales to minors, and smoking in public places.[2-5] The adoption of the Framework Convention on Tobacco Control (FCTC) in 2003 and its subsequent ratification by 177 countries reflects growing global efforts to control tobacco.[6,7] Despite such efforts, tobacco continues to adversely influence global health patterns, leading to 5.7 million deaths, 6.9% of years of life lost, and 5.5% of disability-adjusted life-years (DALYs) in 2010.[8,9] Given the importance of tobacco as a risk to health, monitoring the distribution and intensity of tobacco use is critical for identifying priority areas for action and evaluating progress.

DALY *disability-adjusted life-year*

FCTC *Framework Convention on Tobacco Control*

ST-GPR *spatial-temporal/gaussian process regression*

UI *uncertainty interval*

Early efforts to estimate smoking prevalence[10,11] were based on limited data for many developing countries. Investments in multicountry survey programs have subsequently substantially expanded the primary data available for monitoring. The most recent cross-sectional estimates of smoking prevalence were for 2011.[7] Efforts to track cigarette consumption per capita have been less systematic over time, with results that differ substantially by source.[12-14] *The Tobacco Atlas*[15] has greatly facilitated the policy use of these data by assembling them in 1 location.

Despite improvements in data availability, information on trends has not been synthesized in a systematic and consistent way. This article presents modeled estimates of levels and trends in the prevalence of smoking by age and sex and consumption of cigarettes for 187 countries from 1980 to 2012.

Methods

Data

Prevalence data from major multicountry survey programs were identified, including the Demographic and Health Surveys,[16] the Global Youth Tobacco Surveys,[17] the Global Adult Tobacco Surveys,[18] the World Health Organization (WHO) STEPwise Approach to Surveillance program,[19] the Eurobarometer Surveys,[20] the Living Standards Measurement Studies,[21] the Multiple Indicator Cluster Surveys,[22] the World Health Surveys,[23] and the Reproductive Health Surveys.[24] These sources cover 702 country-years of data. In addition, various national multiyear survey programs including national health surveys, national addiction surveys, and national risk factor surveys were included. We searched 3 large databases—the WHO Global Infobase,[25] the International Smoking Statistics,[26,27] and the Global Health Data Exchange[28]—to identify additional nationally representative surveys. Jointly, these 3 databases contain estimates from published articles, national survey reports, and ministry of health websites. Duplicates across the databases were dropped, with preference given to sources with microdata. In total we used 2102 country-years of data for a total of 38 315 country-year-age-sex data points from 181 countries. There were 6 countries with no data (Afghanistan, Angola, Central African Republic, Guinea-Bissau, Somalia, and Turkmenistan). The methods used to generate estimates for these countries are described in more detail below and in the Supplement. eTable 15 in the Supplement provides a comprehensive list of all sources used in the analysis.

Data from 4 sources, which reported on both manufactured and nonmanufactured tobacco, were used to estimate consumption: (1) the Food and Agriculture Organization of the United Nations on tobacco production as primary commodities for domestic supply (in tonnes, where 1 tonne is approximately equivalent to 1 million sticks of cigarettes) for 168 countries from 1961 to 2009; (2) the Tobacco Yearbook of the US Department of Agriculture, which reported on manufactured cigarettes for domestic consumption (in sticks) for 165 countries from 1960 to 2005; (3) Euromonitor International data on cigarette sales from both retail and illicit trade (in sticks) for 72 countries from 1998 to 2012; and (4) data on the sales of factory-manufactured cigarettes (in sticks) for 18 countries from 1997 to 2012 (Christopher Tan, MBA, written communication, September 2013). Manufactured data were not restricted to machine-made cigarettes; they also included other tobacco types such as roll-your-own cigarettes (see the Supplement).

Definitions

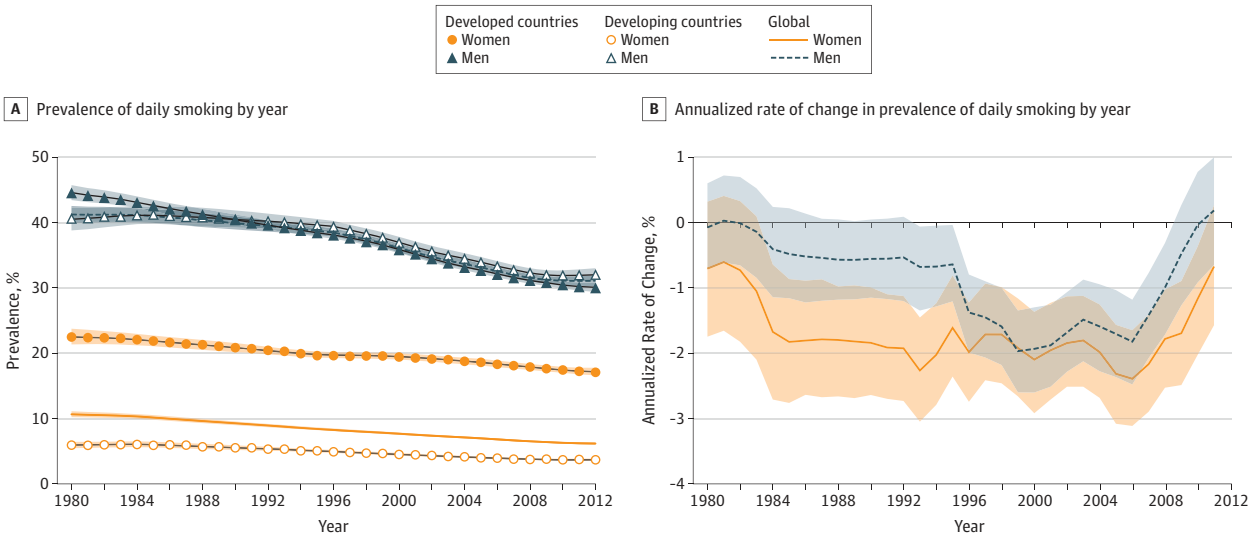
Data sources on prevalence differed in several ways, notably in the way they asked about frequency of smoking and type of tobacco smoked (eTables 1 and 2 in the Supplement). For frequency, the focus was on daily smokers or smoking at least 1 time per day, given the significant health risks associated with daily smoking, even at low levels of consumption.[29-34] The evidence is much less conclusive with respect to differential health outcomes based on the type of tobacco that is smoked.[35,36] In this study, smoking of any tobacco product was included. Thus, the definition of a smoker in this article is someone who smokes any type of tobacco product at least once per day.

For reporting purposes, countries were grouped into developing and developed countries as classified in the Global Burden of Disease Study (eTable 10 in the Supplement).

Data Processing

Algorithms were developed to adjust data reported using other definitions to the reference definition of daily smokers of all tobacco products (eTables 3 and 4 in the Supplement). Data sources that provided information on multiple definitions from the same population were used in ordinary least-squares regressions to approximate the relationship between categories of frequency and categories of type. The coefficients from the regressions were then used to adjust data that were reported using nonstandard definitions (eTables 5-8 in the Supplement). The prediction errors from the adjustment model were added to the standard error so that the uncertainty from the relationship between different definitions is propagated into subsequent analytical steps.

Figure 1. Estimated Age-Standardized Prevalence of Daily Smoking and Annualized Rate of Change, 1980-2012



See the Supplement for full list of developing and developed countries, as defined by the Global Burden of Disease Study. For 6 countries without data on tobacco smoking prevalence (Afghanistan, Angola, Central African Republic, Guineau-Bissau, Somalia, Turkmenistan), estimates were derived based on tobacco consumption and trends in prevalence in neighboring countries. The Supplement has more details on these methods. A, Global (187 countries) age-standardized prevalence estimates by sex and separately for developed countries (50 countries) and developing countries (137 countries) from 1980 to 2012. B, Annualized rate of change in age-standardized prevalence by sex from 1980 to 2012. Annualized rates of change are plotted at the beginning of the time interval they correspond to (eg, the rate of change shown for 2011 is the rate of change between 2011 and 2012). Shaded areas designate 95% uncertainty intervals. Interactive data display at jama.com.

For surveys with microdata, estimates for 5-year age groups and each sex were extracted. The relative prevalence of smoking by age and sex was used to adjust data that were reported for aggregate age groups or both sexes combined. More details are provided in the Supplement.

Data Synthesis

Prevalence

In many cases, multiple sources for the same year implied different levels of prevalence. In other cases, prevalence data were not available for the entire 33-year period of analysis. To address both issues and generate a complete time series that synthesized all available data, a spatial-temporal regression model (ST) and gaussian process regression (GPR) were used. The ST-GPR has been extensively used in global health systematic analyses, most notably in generating many Global Burden of Disease Study estimates.[37-40] Cross-validation analyses were conducted to assess the robustness of the modeling strategy (eTable 9 in the Supplement).

Consumption

Estimating consumption had 2 major analytical challenges. First, none of the consumption sources had a complete time series for all countries. Second, the series varied widely in the level of consumption for a given country and year. To avoid compositional bias in the synthesis of the 4 series on consumption, first, missing values were imputed using the method developed by James et al.[41] The 4 sources were then synthesized into a single estimate of consumption using GPR (see the Supplement).

Age Standardization and Uncertainty Intervals

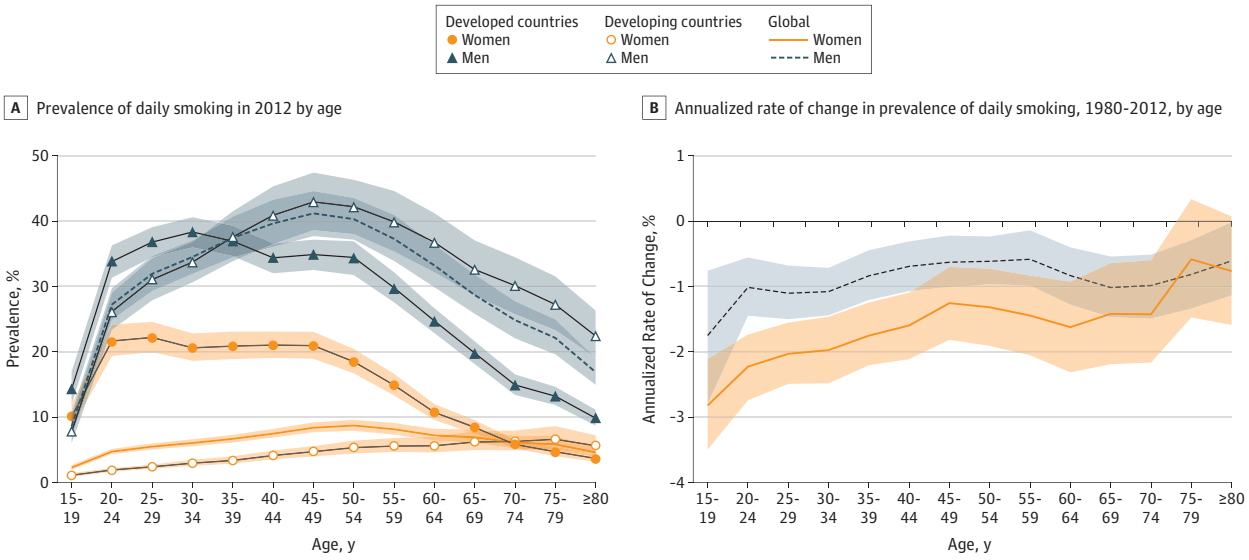
Age-standardized prevalence rates for the population aged 15 years or older were computed using the WHO age standard.[42] Using simulation methods,[43,44] 1000 draws (unbiased random samples) were taken from the uncertainty distributions of prevalence and of consumption. Uncertainty intervals (UIs) for prevalence and consumption were based on computation of the results for each of the 1000 draws; the lower bound of the 95% UI for the final quantity of interest is the 2.5 percentile of the distribution and the upper bound is the 97.5 percentile of the distribution. These UIs reflect multiple sources of uncertainty, including the unexplained variance in the GPR mean function, sampling uncertainty, and uncertainty from mapping from different definitions of frequency and type to daily tobacco smoking.

Results

Global Estimates

Between 1980 and 2012, the estimated age-standardized prevalence of daily tobacco smoking for men declined from 41.2% (95% UI, 40.0%-42.6%) to 31.1% (95% UI, 30.2%-32.0%; $P < .001$), an average annual rate of decline of 0.9% (95% UI, 0.8%-1.0%; $P < .001$) and for women declined from 10.6% (95% UI, 10.2%-11.1%) to 6.2% (95% UI, 6.0%-6.4%; $P < .001$) or 1.7% (95% UI, 1.5%-1.9%; $P < .001$) per year **Figure 1**A; **Interactive** at jama.com). Global progress in reducing the age-standardized prevalence of smokers appeared to fall into 3 phases for both men and women (Figure 1B): modest progress from 1980 to

Figure 2. Estimated Prevalence of Daily Smoking and Annualized Rate of Change by Age, 2012



See the Supplement for full list of developing and developed countries, as defined by the Global Burden of Disease Study. For 6 countries without data on tobacco smoking prevalence (Afghanistan, Angola, Central African Republic, Guinea-Bissau, Somalia, Turkmenistan), estimates were derived based on tobacco consumption and trends in prevalence in neighboring countries. The Supplement has more details on these methods. A, Global (187 countries) prevalence estimates by age group and separately for developed countries (50 countries) and developing countries (137 countries) for 2012. B, Annualized rates of change from 1980 to 2012 by age group and sex. Shaded areas designate 95% uncertainty intervals. Interactive data display at jama.com.

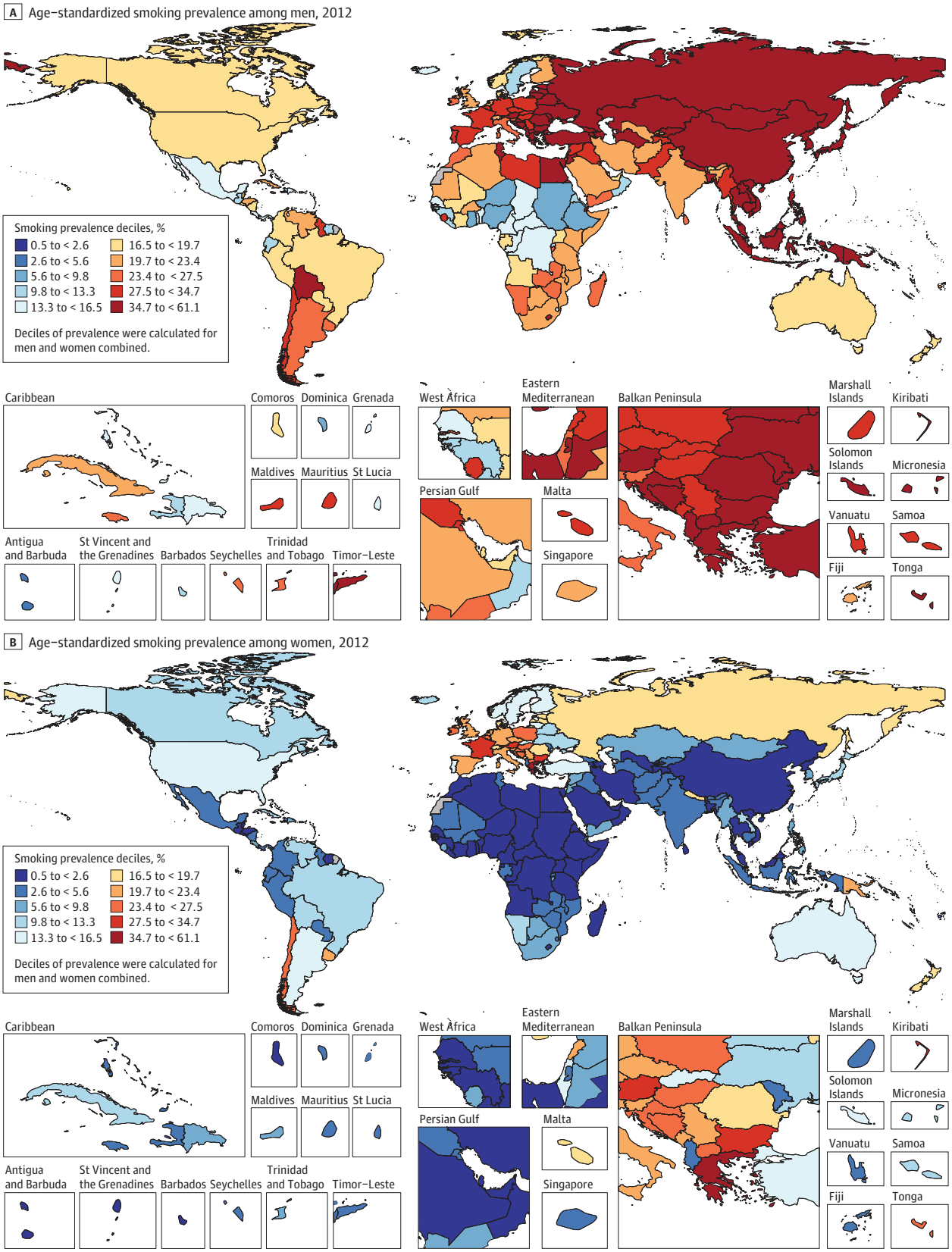
1996 (mean annualized rate of decline, 0.6%; 95% UI, 0.4%-0.8%), followed by a decade of more rapid global progress (mean annualized rate of decline, 1.7%; 95% UI, 1.5%-1.9%; $P < .001$), then a slowdown in reductions from 2006 to 2012 (mean annualized rate of decline, 0.9%; 95% UI, 0.5%-1.3%; $P = .003$), with an apparent increase since 2010 for men. This deceleration in the global trend was in part due to increases in the number of smokers since 2006 in several large countries including Bangladesh, China, Indonesia, and Russia. Since 1980, the global rate of decline in women was consistently higher than in men. eTable 11 in the Supplement provides various summary metrics of tobacco smoking including modeled age-standardized prevalence rates, the number of daily smokers, and total cigarettes consumed each year worldwide. While estimated age-standardized prevalence declined, the growth in population older than 15 years resulted in a continuous increase in the number of men and women who smoke daily, increasing from 721 million (95% UI, 700 million-742 million) in 1980 to 967 million (95% UI, 944 million-989 million; $P < .001$) in 2012. Between 1980 and 2012, the number of cigarettes smoked worldwide increased from 4.96 trillion (95% UI, 4.78 trillion-5.16 trillion) to 6.25 trillion (95% UI, 6.07 trillion-6.44 trillion; $P < .001$). There was no discernible trend in the global average number of cigarettes smoked per smoker per day, remaining around 18.

Figure 2A shows estimated age-specific global prevalence of daily tobacco smoking for men and women in 2012. In men, prevalence increased rapidly in the 15- to 19-year and 20- to 24-year age groups in both developed and developing countries. The highest prevalence rates were seen at age 30 to 34 years in developed countries and age 45 to 49 years in developing countries. After age 35 to 39 years, prevalence was consistently higher in developing countries. Among women, the age pattern of prevalence differed markedly between developed and developing countries. In developed countries, the age pattern of prevalence in women was very similar to men, but at a much lower level. In developing countries, prevalence among women was very low and increased with age, a unique age pattern. The highest prevalence rates (>20%) in women occurred between ages 20 and 49 years in developed countries, while rates higher than 40% were observed among men between the ages of 40 and 54 years in developing countries. Figure 2B shows that in both sexes, the largest annualized rates of change worldwide between 1980 and 2012 were achieved among 15- to 19-year-olds: −1.8% (95% UI, −2.8% to −0.8%; $P = .001$) for men and −2.8% (95% UI, −3.5% to −2.1%; $P < .001$) for women.

Variation in Prevalence Across Countries in 2012

Figure 3 illustrates the variation in 2012 in estimated age-standardized daily smoking prevalence for men and women for the population aged 15 years or older in 187 countries. Estimated prevalence of daily smoking in men ranged from more than 50% in Armenia, Indonesia, Kiribati, Laos, Papua New Guinea, Russia, and Timor-Leste to less than 10% in Antigua and Barbuda, Dominica, Ethiopia, Ghana, Niger, Nigeria, Sao Tome and Principe, Sudan, and Suriname. Low prevalence among men (<20%) occurred in countries in sub-Saharan Africa and in some developed countries that successfully reduced prevalence. Figure 3 also shows that there was considerable within-region variation in smoking rates; for example, while modeled prevalence was generally low in sub-Saharan Africa,

Figure 3. Estimated Age-Standardized Prevalence of Daily Smoking in 2012



Interactive data display at jama.com.

it was high among men in Djibouti and Sierra Leone at 39% (95% UI, 34.0%-43.9%) and 31% (95% UI, 27.3%-34.4%), respectively. Estimated prevalence was very high among men in South, Southeast, and East Asia, with Bhutan the only country with prevalence lower than 20%.

For women, estimated prevalence in 2012 exceeded 30% in Greece, Bulgaria, and Kiribati and was higher than 25% in 7 other countries: Andorra, Austria, Belgium, Chile, France, Hungary, and Macedonia. Conversely, in a number of countries, estimated prevalence for women was 1% or lower, including Azerbaijan, Algeria, Cameroon, Eritrea, Ethiopia, Gambia, Lesotho, Libya, Morocco, Oman, Sri Lanka, and Sudan. There were also large variations within regions, with Chile and Uruguay having much higher estimated prevalence rates than other countries in Latin America, while Albania, Belarus, Finland, Lithuania, Moldova, Norway, Portugal, Slovenia, Sweden, and Ukraine had much lower estimated prevalence than elsewhere in Europe. In Asia, smoking among women in Nepal was comparatively high at 16.9% (95% UI, 14.1%-19.7%). In Oceania, Kiribati, Papua New Guinea, and Tonga had high estimated prevalence among women (>21%) compared with other countries in the region (<16%).

Estimated age-standardized prevalence of daily smoking in men was only weakly correlated with that in women in 2012 (r = 0.38; P < .001), with prevalence in men exceeding that in women in all countries except Sweden (eFigure in the Supplement).

eTables 12 and 14 in the Supplement provide detailed estimates for the 187 countries included in this study for 1980, 1996, 2006, and 2012 of estimated age-standardized prevalence of daily tobacco smoking for men and women aged 15 years or older, estimated number of smokers aged 15 years or older for men and women, estimated total cigarette consumption, estimated cigarette consumption per adult per year, and estimated cigarette consumption per smoker per day.

Annualized Rates of Change in the Prevalence of Tobacco Smoking

Figure 4 compares the annualized rate of change in the estimated age-standardized prevalence of daily tobacco smoking among persons aged 15 years or older with the estimated baseline prevalence in 1980 separately for men and women. Annualized rate of change captures the relative reduction in smoking prevalence and was largely uncorrelated with initial prevalence levels in 1980 (r = −0.26; P < .001 for men and r = −0.13; P = .08 for women). For men, annualized rates of decline of 2% or more occurred in 17 countries, with the greatest rates of decline observed in Canada, Iceland, Mexico, Norway, and Sweden. During the same period, 6 countries (Cote d'Ivoire, Croatia, Kazakhstan, Mauritania, Saudi Arabia, and Serbia) exhibited statistically significant increases in prevalence (P < .05 for all countries). For women, annualized rates of decline greater than 2% were achieved in 22 countries, while 12 countries exhibited statistically significant increases in prevalence since 1980. Bolivia, Canada, Denmark, Iceland, Israel, Norway, Sweden, and the United States all had prevalence rates in 1980 higher than 20% but achieved annualized rates of decline of greater than 2%, whereas Austria, Bulgaria, and Greece, which also had prevalence rates greater than 20% in 1980, showed statistically significant increases since then.

eTable 13 in the Supplement provides the annualized rates of change for the 3 periods (1) 1980-1995, (2) 1996-2005, and (3) 2006-2012. For men, the mean annualized rates of change across countries accelerated from −0.4% (95% UI, −0.6% to −0.2%) to −1.7% (95% UI, −1.9% to −1.4%; P < .001) between periods 1 and 2 and slowed to −0.8% (95% UI, −1.3% to −0.2%; P = .005) in period 3. For women, the mean annualized rates of change were not significantly different across the 3 periods and went from −1.6% (95% UI, −1.9% to −1.3%) in period 1 to −1.9% (95% UI, −2.2% to −1.6%; P = .08) in period 2 and to −1.6% (95% UI, −2.2% to −1.1%; P = .21) in period 3.

Number of Cigarettes Smoked

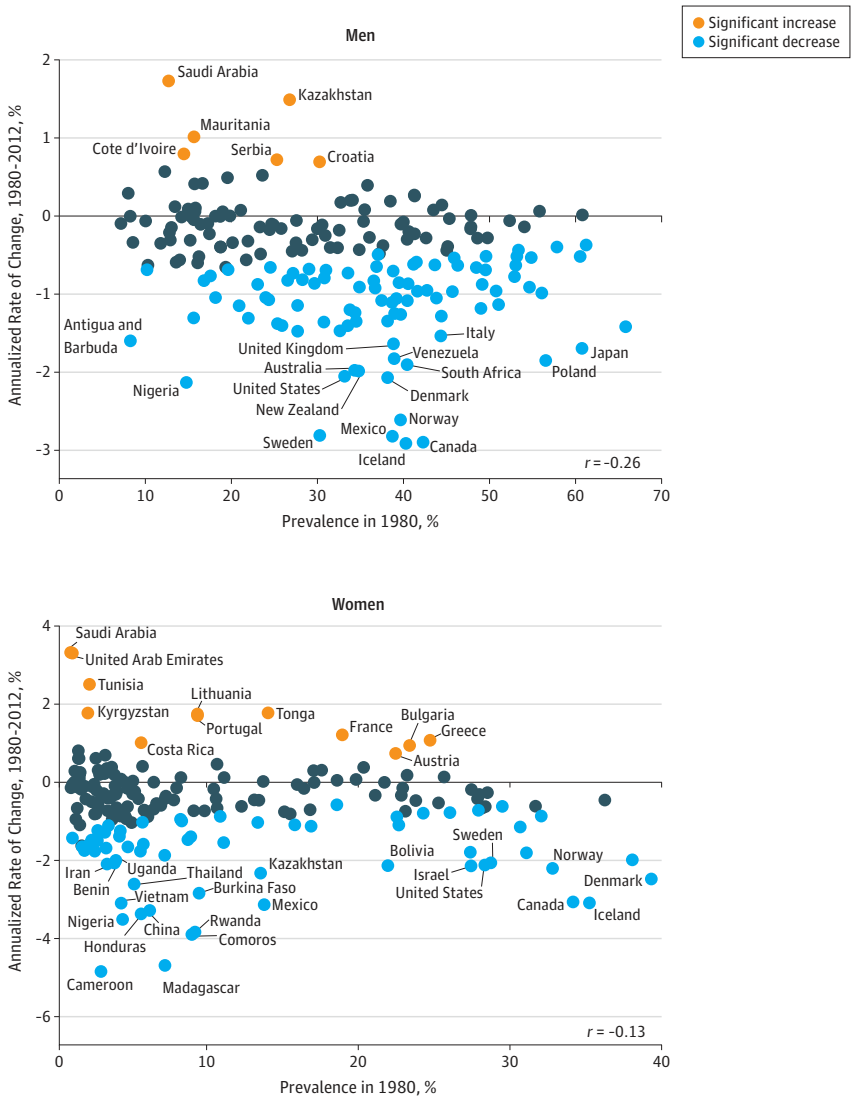
In 2012, there were 34 countries where the average number of cigarettes per daily smoker per day was less than 10, 78 countries with average consumption between 10 and 20 cigarettes per day, and 75 countries with consumption greater than 20 cigarettes per day (eTable 14 in the Supplement). Total exposure to tobacco and associated risks to health are related to both intensity and prevalence. **Figure 5** demonstrates how total exposure varied across countries by categorizing them into 6 groups based on estimated prevalence (below or above the global average) and cigarettes per daily smoker per day: low (<10), medium (10-20), and high (>20). The greatest health risks are likely to occur in countries with high prevalence and high consumption, including China, Greece, Ireland, Italy, Japan, Kuwait, Korea, the Philippines, Uruguay, Switzerland, and several countries in Eastern Europe, such as Russia. Several countries had high prevalence but low consumption, including Bangladesh, Bolivia, Chile, Nepal, the Solomon Islands, and Timor-Leste. There was no correlation between estimated prevalence and number of cigarettes smoked per smoker per day in 2012 (r = −0.04; P = .54), emphasizing that both need to be taken into account when monitoring a population's exposure to tobacco.

Discussion

Global estimated age-standardized prevalence of daily tobacco smoking declined by 25% (95% UI, 21.4%-27.9%; P < .001) for men and by 42% (95% UI, 39.0%-45.0%; P < .001) for women between 1980 and 2012. The substantial population growth over this period contributed to a 41% (95% UI, 34.6%-47.2%; P < .001) increase in the number of male daily smokers and a 7% (95% UI, 2.0%-13.0%; P = .005) increase for female smokers. The number of cigarettes consumed worldwide increased by 26% (95% UI, 20.5%-31.8%; P < .001) during the same period, confirming that the global tobacco market continued to grow. During the past 3 decades, the pace of reduction in prevalence was greatest between 1996 and 2006 but was subsequently followed by a period of slower reductions at the global level.

Our trend analysis revealed several countries with large reductions in the prevalence of smoking among men, including Canada and Iceland, with prevalences in 2012 estimated at 16.7% (95% UI, 15.4%-18.3%) and 15.9% (95% UI, 14.6%-

Figure 4. Annualized Rate of Change in Prevalence Between 1980 and 2012 Compared With Estimated Prevalence in 1980



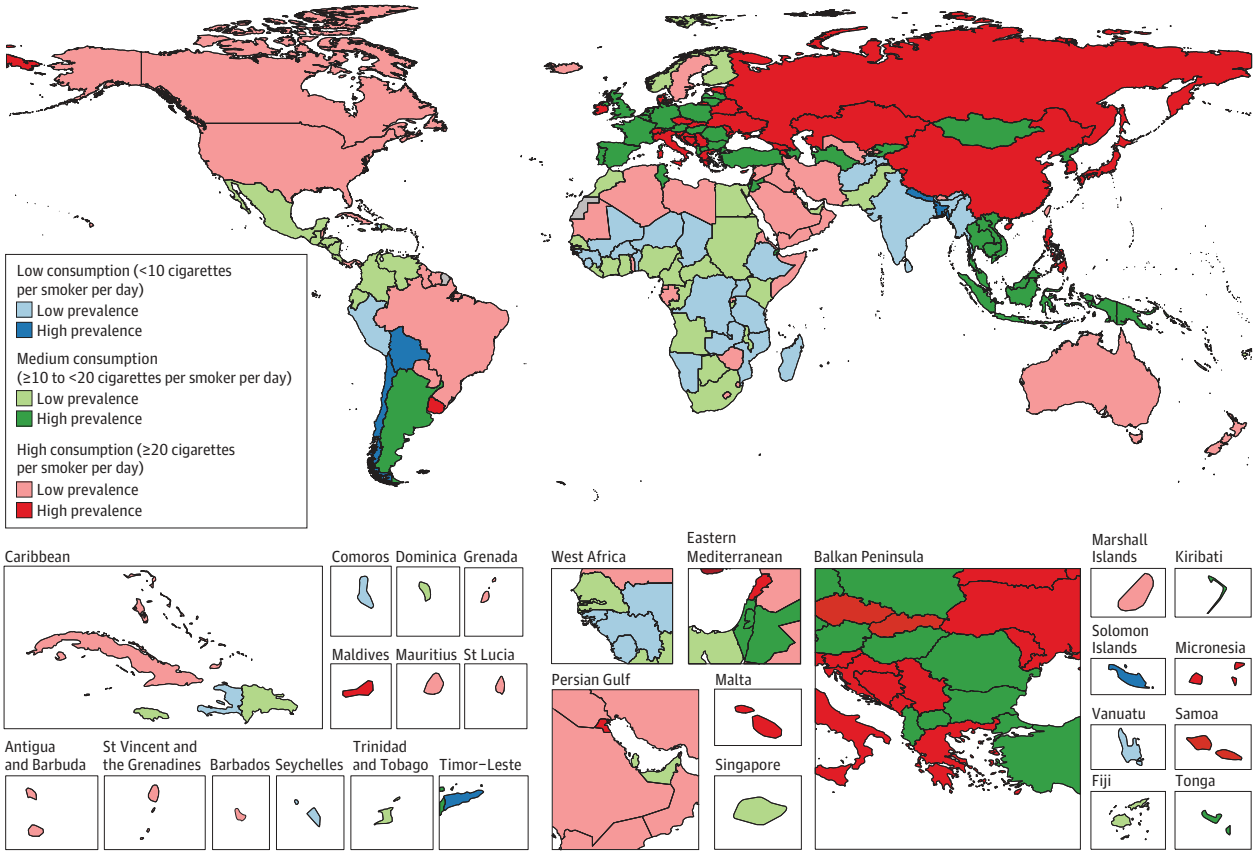
Annualized rate of change between 1980 and 2012 in estimated age-standardized prevalence of daily smoking compared with estimated age-standardized prevalence of daily smoking in 1980 for men (top) and women (bottom) for 187 countries. Orange data points represent countries that experienced statistically significant increases between 1980 and 2012 based on a 1-tailed test at the *P*=.05 significance level. Bright blue data points represent countries that experienced statistically significant decreases between 1980 and 2012 based on a 1-tailed test at the *P*=.05 significance level. Country names are shown for all countries that experienced statistically significant increases and for countries with statistically significant decreases of at least 1.5% per year for men and 2.0% per year for women.

17.2%), respectively. In Sweden, however, where estimated prevalence of daily smoking among men was 12.3% (95% UI, 11.0%-13.8%) in 2012, daily consumption increased since 1980 from 16.1 (95% UI, 14.0-18.2) to 22.5 (95% UI, 19.9-25.8; $P < .001$) cigarettes per smoker per day, and there was also an increase in the consumption of snus, a form of oral tobacco that may be useful in helping smokers to quit.[45,46] Although the health effects of snus remain controversial,[47,48] it is likely that the recent trends in Sweden will result in reductions in disease burden attributable to tobacco in the coming decades.[46] Several middle-income countries have also attained low prevalence in 2012, including Barbados (10.5%; 95% UI, 8.3%-13.1%), Costa Rica (16.1%; 95% UI, 13.9%-18.4%), the Dominican Republic (14.5%; 95% UI, 12.4%-16.7%), Ecuador (10.3%; 95% UI, 8.4%-12.3%), and Panama (13.8%; 95% UI, 11.5%-16.1%).

Estimated prevalence of daily smoking in women varied greatly across high-income countries in 2012, from less than 15% in Canada, Iceland, Israel, Japan, Sweden, and the United States to greater than 26% in Austria, Belgium, Chile, France, and Greece. Female estimated prevalence never exceeded 5% in many middle-income countries, while in others, including Bulgaria, Hungary, and Lebanon, prevalence rates exceeded 20%. Overall, estimated prevalence rates between men and women were weakly correlated. In 2012, 12 countries (including China and Indonesia), with male estimated prevalence greater than 40% and female estimated prevalence lower than 5%, accounted for almost 40% of the world's smokers.

Four countries were successful in achieving reductions of greater than 50% in both male and female smoking prevalence since 1980: Canada, Iceland, Mexico, and Norway. More detailed analyses of the effect of implementation of proven policy strategies and how they were enacted in these countries[49-53] could provide valuable insights for tobacco control elsewhere.

Figure 5. Age-Standardized Smoking Intensity and Prevalence in 2012



Map classifying 187 countries by estimated age-standardized prevalence of daily smoking for both sexes combined and mean consumption per daily smoker per day. Countries were classified as low prevalence if the estimated age-standardized prevalence for both sexes combined was below the median across all countries (18.7%) and as high prevalence otherwise. Countries were classified as high consumption if mean consumption per daily smoker was greater than or equal to 20 cigarettes per day; medium consumption if mean consumption per daily smoker was greater than or equal to 10 and less than 20 cigarettes per day; and low consumption if mean consumption per daily smoker was less than 10 cigarettes per day. Insets display countries that would otherwise be difficult to see on the map.

The estimated prevalence trends in this study provide an opportunity to assess the feasibility of the voluntary target for tobacco prevalence adopted by WHO member states in 2013, which implies an annual rate decline of 3%. This pace of decline was not achieved in any country during the period 1980 to 2012 for men and was observed only in countries that started with very low prevalence rates for women. Over shorter periods, annual rates of change greater than 3% were observed. Setting targets that are aspirational can be an effective motivator for action but can also act as a disincentive if they are too ambitious. To achieve the levels proposed in the voluntary targets would require sustained and immediate action.

The FCTC was adopted by the World Health Assembly in 2003 and has since been ratified by 177 countries.[6] The FCTC's implementation is now being scaled up in many countries,[7] including advertising bans, bans of smoking in public places, increased tobacco taxation, mass-media countermarketing, and other strategies. The FCTC holds great promise; in some countries, like New Zealand, smoking prevalence rates have been steadily declining since the implementation of the Smoke-free Legislation amendment in 2003 and other health warning policies in 2007. Although preliminary evidence of the effect of concerted policy action in some countries is encouraging, the deceleration in reducing prevalence of daily smoking at the global level since 2006 is cause for concern and highlights the critical importance of careful and timely monitoring of changes in tobacco prevalence as new policies are adopted and implemented.

Trends in both prevalence and consumption are critical to monitor. The pattern of high prevalence and comparatively low cigarettes per smoker per day seen in South Asia and Southeast Asia is particularly noteworthy. While less harm is associated with low-intensity smoking compared with high-intensity smoking,[33,34,54,55] the harm is still substantial. Heightened efforts are required in countries with low consumption to ensure that it remains low.

This study has several limitations. First, where microdata were not available, data from published tabulations were used. Second, additional uncertainty was introduced from our

crosswalk procedure into the final estimates. This could have resulted in overestimation or underestimation of prevalence levels. Third, the UIs are likely underestimated (see the Supplement for details), although the cross-validation analysis suggests that the magnitude of the underestimation is small. Fourth, because of data sparseness in some countries, the age- and sex-splitting algorithm was based on the relative age and sex patterns of prevalence within Global Burden of Disease Study superregions for each decade. It is possible that the regional pattern may not be consistent with the pattern observed within each country. Fifth, in countries where data were sparse, the estimated trend was largely based on the trend in the consumption of cigarettes per capita. Sixth, there may exist sources of error in our estimation of consumption, as sometimes the time series from different sources were inconsistent and within series there were often large fluctuations from year to year. Furthermore, consumption data for countries with small populations, such as Caribbean island nations, could be affected by tobacco sales to travelers. Seventh, age-standardized rates reported in this study were estimated following the WHO population standard.[42] This standard is younger than the age structure in many high-income countries. Eighth, the analysis relied on self-reported data, and it is possible that reporting bias varied across countries and over time. Finally, given that the focus of this study was daily tobacco smokers, the number of cigarettes smoked per day was overestimated because it was calculated from dividing all cigarettes consumed by the number of daily smokers rather than all smokers.

Although in several countries substantial uncertainty remains in monitoring tobacco exposure and estimating the disease burden associated with it, there can be no doubt that both are large. Policies and strategies to improve global health must include comprehensive efforts to control tobacco use, as envisaged under the FCTC. But implementation of policies is not enough; countries, and the global health community, need to collect timely, reliable, and detailed information on the effect of those policies, particularly among vulnerable populations and those being directly targeted by the tobacco industry. If global tobacco control is to benefit from concerted policy action, population-level surveillance of tobacco use and its health effects needs to be strengthened and routinely used to evaluate the impact of tobacco control strategies.

Conclusions

Despite progress in reducing prevalence of daily smoking since 1980, the number of smokers has increased steadily worldwide, and there are preliminary indications that global prevalence among men increased in recent years. Although many countries have implemented control policies, intensified tobacco control efforts are particularly needed in countries where the number of smokers is increasing.

ARTICLE INFORMATION

Author Contributions: Dr Gakidou had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Ng, Freeman, Lopez, Murray, Gakidou.
Acquisition of data: Ng, Freeman, Fleming, Robinson, Thomson, Wollum, Sanman, Wulf, Lopez, Murray, Gakidou.
Analysis and interpretation of data: All authors.
Drafting of the manuscript: Ng, Freeman, Lopez, Murray, Gakidou.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Ng, Freeman, Fleming, Dwyer-Lindgren, Murray, Gakidou.
Obtained funding: Murray, Gakidou.
Administrative, technical, or material support: Ng, Fleming, Robinson, Thomson, Wollum, Sanman, Murray, Gakidou.
Study supervision: Ng, Lopez, Murray, Gakidou.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Dr Lopez reports consultancy for the Institute for Health Metrics and Evaluation. No other disclosures were reported.

Funding/Support: This research was conducted as part of the Global Burden of Diseases, Injuries, and Risk Factors Study 2.0. This study is supported by a grant from the Bill & Melinda Gates Foundation and the State of Washington.

Role of the Sponsors: The funding organizations had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

Additional Contributions: We thank the following individuals for their contributions to this effort: Stan Biryukov, BS, Paria Naghavi, BESc, Lee Richardson, BS, and Allen Roberts, BS, all from the Institute for Health Metrics and Evaluation (IHME), for their work extracting and cleaning data; Piya Hanvoravongchai, PhD, Thailand Research Center for Health Services System, Hideki Higashi, PhD, IHME, Hmwe Hmwe Kyu, PhD, IHME, A. J. Lanyon, PhD, Australian Bureau of Statistics, Stephen Lim, PhD, IHME, Mohsen Naghavi, PhD, IHME, Stein Emil Vollset, PhD, IHME, and Theo Vos, PhD, IHME, for their assistance in data acquisition; Stephanie Atkinson, MLIS, Michelle Darbous, MSc, and Erica Nelson, MLIS, all from IHME, for data collection, cataloguing, and fulfilling use agreements; Evan Laurie, BS, IHME, for information technology support; and Erin Mullany, BA, IHME, for administrative support and editorial assistance. No compensation was provided for contributions.

REFERENCES

1. *Smoking and Health: Report of the Advisory Committee to the Surgeon General of the Public Health Service, 1964*. Washington, DC: US Department of Health, Education, and Welfare; 1964. http://profiles.nlm.nih.gov/NN/B/B/M/Q/. Accessed December 9, 2013.

2. Wakefield MA, Durkin S, Spittal MJ, et al. Impact of tobacco control policies and mass media campaigns on monthly adult smoking prevalence. *Am J Public Health*. 2008;98(8):1443-1450.

3. Farrelly MC, Pechacek TF, Thomas KY, Nelson D. The impact of tobacco control programs on adult smoking. *Am J Public Health*. 2008;98(2):304-309.

4. Jha P. *Curbing the Epidemic: Governments and the Economics of Tobacco Control*. Herndon, VA: World Bank Publications; 1999.

5. US Department of Health and Human Services. *Ending the Tobacco Epidemic: A Tobacco Control Strategic Action Plan for the US Department of Health and Human Services*. Washington, DC: Office of the Assistant Secretary for Health; 2010.

6. World Health Organization. WHO Framework Convention on Tobacco Control. http://www.who.int/fctc/text_download/en/index.html. Accessed October 14, 2013.

7. World Health Organization. *WHO Report on the Global Tobacco Epidemic, 2013*. Geneva, Switzerland: World Health Organization; 2013. http://www.who.int/tobacco/global_report/2013/en/. Accessed December 9, 2013.

8. Institute for Health Metrics and Evaluation. Global Burden of Disease (GBD) Visualizations. http://www.healthmetricsandevaluation.org/gbd/visualizations/country. Accessed October 16, 2013.

9. Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380(9859):2224-2260.

10. World Health Organization. *Tobacco or Health: A Global Status Report*. Geneva, Switzerland: World Health Organization; 1997.

11. Lopez AD, Collishaw NE, Piha T. A descriptive model of the cigarette epidemic in developed countries. *Tob Control*. 1994;3(3):242-247.

12. US Department of Agriculture. Tobacco Yearbook USDA Dataset. http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1392. Accessed October 15, 2013.

13. Euromonitor International. Tobacco industry market research. http://www.euromonitor.com/tobacco. Accessed October 15, 2013.

14. Food and Agriculture Organization of the United Nations. *Projections of Tobacco Production, Consumption and Trade to the Year 2010*. http://www.fao.org/docrep/006/y4956e/y4956e00.HTM. Accessed October 15, 2013.

15. World Lung Foundation; American Cancer Society. *The Tobacco Atlas, 4th Edition*. http://tobaccoatlas.org/. Accessed October 15, 2013.

16. US Agency for International Development. Measure DHS: Demographic and Health Surveys. http://www.measuredhs.com/. Accessed October 15, 2013.

17. World Health Organization. Global Youth Tobacco Survey. http://www.who.int/tobacco/surveillance/gyts/en/. Accessed October 15, 2013.

18. World Health Organization. Global Adult Tobacco Survey. http://www.who.int/tobacco/surveillance/survey/gats/en/. Accessed October 15, 2013.

19. World Health Organization. STEPwise Approach to Surveillance. http://www.who.int/chp/steps/en/. Accessed October 15, 2013.

20. European Commission. Eurobarometer Surveys. http://ec.europa.eu/public_opinion/index_en.htm. Accessed October 16, 2013.

21. World Bank. Living Standards Measurement Study. http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:21610833~pagePK:64168427~piPK:64168435~theSitePK:3358997,00.html. Accessed October 16, 2013.

22. United Nations Children's Fund. Multiple Indicator Cluster Survey. http://www.unicef.org/statistics/index_24302.html. Accessed October 16, 2013.

23. World Health Organization. World Health Survey. http://apps.who.int/healthinfo/systems/surveydata/index.php/catalog/whs/about. Accessed October 16, 2013.

24. Centers for Disease Control and Prevention. Reproductive Health Surveys. http://www.cdc.gov/reproductivehealth/Global/surveys.htm. Accessed October 16, 2013.

25. World Health Organization. WHO Global InfoBase. https://apps.who.int/infobase/. Accessed October 15, 2013.

26. P. N. Lee Statistics and Computing. International Mortality and Smoking Statistics. http://www.pnlee.co.uk/IMASS.htm. Accessed October 15, 2013.

27. Forey B. *International Smoking Statistics: A Collection of Historical Data From 30 Economically Developed Countries*. Oxford, England: Wolfson Institute of Preventive Medicine, Oxford University Press; 2002.

28. Institute for Health Metrics and Evaluation. Global Health Data Exchange. http://ghdx.healthmetricsandevaluation.org/. Accessed October 15, 2013.

29. Bjartveit K, Tverdal A. Health consequences of smoking 1-4 cigarettes per day. *Tob Control*. 2005;14(5):315-320.

30. Willett WC, Green A, Stampfer MJ, et al. Relative and absolute excess risks of coronary heart disease among women who smoke cigarettes. *N Engl J Med*. 1987;317(21):1303-1309.

31. Rosengren A, Wilhelmsen L, Wedel H. Coronary heart disease, cancer and mortality in male middle-aged light smokers. *J Intern Med*. 1992;231(4):357-362.

32. Pope CA III, Burnett RT, Krewski D, et al. Cardiovascular mortality and exposure to airborne fine particulate matter and cigarette smoke: shape of the exposure-response relationship. *Circulation*. 2009;120(11):941-948.

33. Pope CA III, Burnett RT, Turner MC, et al. Lung cancer and cardiovascular disease mortality associated with ambient air pollution and cigarette smoke: shape of the exposure-response relationships. *Environ Health Perspect*. 2011;119(11):1616-1621.

34. Pirie K, Peto R, Reeves GK, Green J, Beral V; Million Women Study Collaborators. The 21st century hazards of smoking and benefits of stopping: a prospective study of 1 million women in the UK. *Lancet*. 2013;381(9861):133-141.

35. World Health Organization. *Tobacco: Deadly in Any Form or Disguise*. Geneva, Switzerland: World Health Organization; 2006. http://www.who.int/tobacco/communications/events/wntd/2006/Report_v8_4May06.pdf. Accessed December 9, 2013.

36. Shopland D. *Cigars: Health Effects and Trends*. Vol 9. Darby, PA: Diane Publishing Co; 1998. Smoking and Tobacco Control Monograph.

37. Wang H, Dwyer-Lindgren L, Lofgren KT, et al. Age-specific and sex-specific mortality in 187 countries, 1970-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380(9859):2071-2094.

38. Murray CJ, Rosenfeld LC, Lim SS, et al. Global malaria mortality between 1980 and 2010: a systematic analysis. *Lancet*. 2012;379(9814):413-431.

39. Hogan MC, Foreman KJ, Naghavi M, et al. Maternal mortality for 181 countries, 1980-2008: a systematic analysis of progress towards Millennium Development Goal 5. *Lancet*. 2010;375(9726):1609-1623.

40. Rajaratnam JK, Marcus JR, Flaxman AD, et al. Neonatal, postneonatal, childhood, and under-5 mortality for 187 countries, 1970-2010: a systematic analysis of progress towards Millennium Development Goal 4. *Lancet*. 2010;375(9730):1988-2008.

41. James SL, Gubbins P, Murray CJ, Gakidou E. Developing a comprehensive time series of GDP per capita for 210 countries from 1950 to 2015. *Popul Health Metr*. 2012;10(1):12.

42. Ahmad OB, Boschi-Pinto C, Lopez AD, Murray CJ, Lozano R, Inoue M. *Age Standardization of Rates: A New WHO Standard*. Geneva, Switzerland: World Health Organization; 2001. http://www.who.int/healthinfo/paper31.pdf. Accessed December 9, 2013.

43. Salomon JA, Murray CJL. The epidemiologic transition revisited: compositional models for causes of death by age and sex. *Popul Dev Rev*. 2002;28(2):205-228.

44. Mathers CD, Salomon JA, Ezzati M, Begg S, Hoorn SV, Lopez AD. Sensitivity and uncertainty analyses for burden of disease and risk factor estimates. In: Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ, eds. *Global Burden of Disease and Risk Factors*. Washington, DC: World Bank; 2006. http://www.ncbi.nlm.nih.gov/books/NBK11802/. Accessed October 16, 2013.

45. Ramström LM, Foulds J. Role of snus in initiation and cessation of tobacco smoking in Sweden. *Tob Control*. 2006;15(3):210-214.

46. Foulds J, Ramstrom L, Burke M, Fagerström K. Effect of smokeless tobacco (snus) on smoking and public health in Sweden. *Tob Control*. 2003;12(4):349-359.

47. England LJ, Levine RJ, Mills JL, Klebanoff MA, Yu KF, Cnattingius S. Adverse pregnancy outcomes in snuff users. *Am J Obstet Gynecol*. 2003;189(4):939-943.

48. Luo J, Ye W, Zendehdel K, et al. Oral use of Swedish moist snuff (snus) and risk for cancer of the mouth, lung, and pancreas in male construction workers: a retrospective cohort study. *Lancet*. 2007;369(9578):2015-2020.

49. Green LW, Eriksen MP, Bailey L, Husten C. Achieving the implausible in the next decade's tobacco control objectives. *Am J Public Health*. 2000;90(3):337-339.

50. Stephens T, Pederson LL, Koval JJ, Macnab J. Comprehensive tobacco control policies and the smoking behaviour of Canadian adults. *Tob Control*. 2001;10(4):317-322.

51. Hallkjelsvik T, Lund KE, Kraft P, Rise J. Fear appeals in advanced tobacco control environments: the impact of a national mass media campaign in Norway. *Health Educ Res*. 2013;28(5):888-897.

52. Andalón M. Clean indoor air policies and smoking in Mexico. *Econ Pap J Appl Econ Policy*. 2013;32(1):10-31.

53. Crosbie E, Sebrié EM, Glantz SA. Strong advocacy led to successful implementation of smokefree Mexico City. *Tob Control*. 2011;20(1):64-72.

54. Kenfield SA, Wei EK, Rosner BA, Glynn RJ, Stampfer MJ, Colditz GA. Burden of smoking on cause-specific mortality: application to the Nurses' Health Study. *Tob Control*. 2010;19(3):248-254.

55. Kenfield SA, Stampfer MJ, Rosner BA, Colditz GA. Smoking and smoking cessation in relation to mortality in women. *JAMA*. 2008;299(17):2037-2047.