Estimating the impact of cigarette smoking on life expectancy from 1950 to 2000

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In this study, Theodore R. Holford from the Department of Biostatistics at the Yale University School of Public Health estimates the impact of cigarette smoking on life expectancy between 1950 and 2000

The smoking history generator (SHG) was developed by the Cancer Intervention and Surveillance Modeling Network (CISNET) Lung Group to characterize the smoking behavior in a population. [1] It provides estimates of never, current, and former smoker prevalence by age for different cohorts.

In addition, it gives estimates of initiation and cessation probabilities, so that one can determine the length of exposure and the time since individuals ceased smoking. Finally, it gives estimates of the distribution of the number of cigarettes smoked per day. These were initially generated for the U.S. but have also been used in other countries. This approach has been extended for use in each state in the U.S. [2]

Smoking histories are best understood by evaluating the pattern of behavior for birth cohorts because the effects evolve over time, depending on when individuals start to smoke, and when they quit. To understand the magnitude of the impact of cigarette smoking within each state, one first estimates mortality rates in each state [3], and then compares that mortality to the mortality of individuals who never smoked.

Previous articles have described the method used to estimate SHG parameters, and the approach that can be extended for application to subsets of the population. [1,2] In this article, we use those estimates to partition the mortality estimates to give estimates of mortality by smoking history status, including estimates of mortality rates for never-smokers. Life expectancy estimates for cohorts provide a summary of the lifetime experience of the cohort, and a comparison between an estimate for the population and never smokers, quantifies the harm done by cigarette smoking.

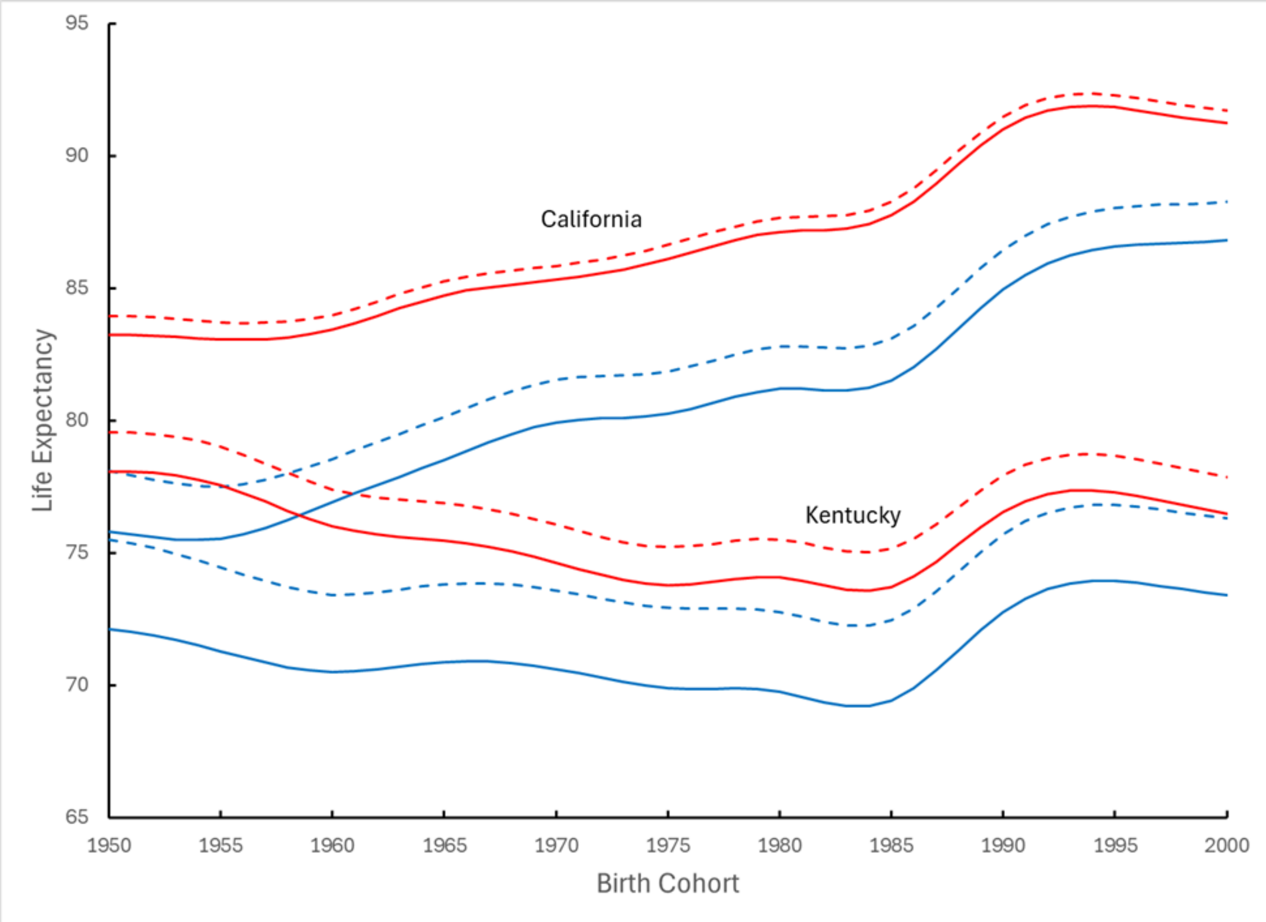

Figure 1. Life expectancy for cohorts born from 1950 to 2000 in California and Kentucky, by sex [females (red) and males (blue)], for everyone in each state (solid) and never smokers (broken).

Age-period-cohort model for mortality

Data on all-cause mortality for ages 0-84 and years 1969-2020 was obtained with permission from the CDC National Center for Health Statistics (NCHS). [4-7] Population estimates by age and year were obtained from the Surveillance, Epidemiology and End Results (SEER) Program website. [8] An age-period-cohort model was fitted to the data for each state, which provided good estimates of the mortality rate even for small states, which would tend to have less precision for good estimates of mortality rates. [3]/sup>

The model fitted to these data had terms for each temporal parameter, and these were characterized by constrained cubic splines, which gave the trends between specified knots as cubic polynomials. Before and after knots at the extremes, the function was a straight line. For age, the final knot was age 35, so the log mortality rate was forced to be linear for older ages. Some 200 years ago, Gompertz noted the linear relationship between log mortality and age [9], and this model still works well today. Fitted values from this model provided estimates of the mortality rates for ages 0-119 for birth years 1900-2000.

Comparing life expectancy trends

To illustrate the effect of smoking in different states, consider California and Kentucky. A comparison of the smoking patterns in these two states is described in Holford, [3] showing very different trends in each state. California has been relatively aggressive in adopting policies affecting cigarette smoking, including taxes on cigarette purchases and clean air laws limiting places where smoking is allowed. This has resulted in lower rates of smoking initiation and increased rates of cessation when compared to Kentucky, which is a tobacco-producing state that has done little to control smoking. The effect can be seen clearly in the SHG parameters characterizing exposure to cigarette smoke. [2]

Figure 1 shows the cohort life expectancy in California and Kentucky (solid lines) for both females and males. In 1950, life expectancy was higher in California, but that difference has grown considerably since. The trend for Kentucky has remained flat, while California has improved during that time. In addition, the bends in the curves for each sex in a state are similar, reflecting the similar impact in trends affecting health on life expectancy.

Also shown in Figure 1 are the trends in life expectancy for never-smokers (broken lines), which are higher than the population estimates. The differences between the population and never smokers are greater in Kentucky than California, reflecting the impact of higher exposure in the state. In 1950, female life expectancy was 78.1 years and 79.6 in never smokers, a shortening of 1.5 years. The reduced exposure in 2000 resulted in estimates of 76.5 and 77.9, a difference of 1.4 years. For males, the life expectancies were 72.1 and 75.5, i.e., smoking shortened life by 3.4 years in 1950, and 73.4 and 76.3 in 2000, a difference of 2.9 years. In California females, the life expectancy was 91.3 in 2000, and the effect of cigarette exposure changed from 0.8 in 1950 to 0.4 years in 2000. For males, cohort life expectancy in 2000 was 88.3, and the difference from that of never-smokers decreased from 2.3 to 1.4 years.

Mortality changes and the effect of cigarettes

The usual approach for estimating life expectancy uses estimated mortality rates each year and assumes they apply to a hypothetical population. Of course, no such population exists because each year consists of a mix of individuals born in different years. Behavior that affects mortality risk changes with generations, so this does not capture the experience that would be expected for different generations. Cohort life expectancy offers an alternative that may better capture the experience of a population.

The analysis shown focuses on the impact that cigarette smoking has had in two U.S. states. From 1950 to 2000, cigarette smoking declined in both states, so the difference between the population’s life expectancy and that of non-smokers declined. Kentucky has taken fewer measures to control smoking, and one can see that the impact on smoking is considerably higher than in California. In addition, the change in this impact from 1950 to 2000 is less in Kentucky because California has had more control over cigarette smoking.

Mortality is affected by many factors other than cigarette smoking, including drug use, environmental safety, social interactions, vaccination, and access to healthcare. California is generally better off than Kentucky, giving it better access to healthcare, and this has certainly contributed to the overall increased life expectancy and the upward trend shown in this analysis. However, it has also reduced cigarette smoking exposure, as shown in this analysis. Not only is the mortality of the state closer to that of its never smokers, but gains seen from 1950 to 2000 are generations, so this does not capture the experience that would be expected for different generations. Cohort life expectancy offers an alternative that may better capture the experience of a population.

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While the model used to estimate mortality does provide a good fit to observed data, none of the cohorts span the entire age range for the years covered, and the most recent cohort would continue to after 2100. While the Gompertz assumption has worked well for many years, it is possible that this could change. However, this analysis does indicate that the public health measures used to control smoking are providing important advantages to the population.

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