Cigarette smoking focus: A modeling approach for estimating the impact of health programs

openaccessgovernment.org/article/cigarette-smoking-focus-a-modeling-approach-for-estimating-the-impact-of-health-programs/177453

24 May 2024

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Theodore R. Holford from Yale University charts a modeling approach for estimating the impact of health programs in this cigarette smoking research focus

Cigarette smoking is one of the most harmful causes of increasing illness risk and shortening life. Its effect was not expected initially, but the recognition of a growing epidemic in lung cancer became apparent in the middle of the twentieth century, stimulating a research effort to find the cause of an alarming trend. This work demonstrated the strong association between smoking and lung cancer. Still, as work continued, it became clear that lung cancer was but the first of a long list of other diseases affecting the lungs, the heart, and other organs.

Exposure to cigarette smoking is primarily from individuals adopting this behavior and exposing themselves to the harmful components of smoke from burning tobacco. The behavior is addictive, making it difficult for users to quit once their habit is established. To

control exposure, there is a need to intervene in ways that reduce initiation, increase cessation, lower levels of smoking, and surveil those at high risk of related diseases to provide prompt treatment.

Public health strategies try to interrupt an individual's smoking behavior by discouraging initiation among those who have never smoked or by encouraging current smokers to quit. The entire progression of starting and quitting affects overall exposure and risk. To assess the level of exposure for individuals in the population, it is essential to characterize the varying levels of exposure by quantifying the distribution of smoking history.

Cigarette smoking trends in the U.S.

The Cancer Intervention and Surveillance Modeling Network (CISNET)-Lung Working Group has developed population models for cigarette smoking trends in the U.S. that describe the history of the population since the start of the twentieth century, changing dynamically over time with births, deaths, and migration. [1, 2] Following the population in time, birth cohorts are mostly the same group of individuals that are followed as they get older. Each cohort retains aspects of their lifestyle exposures from when they were younger.

In addition, individuals move away from the country, others move in, and some die. Following smoking behavior for each birth cohort in a population provides more detailed information on how histories are changing. Well- designed health surveys that include questions on smoking can be used to estimate parameters that describe smoking histories for a birth cohort. CISNET has used the National Health Interview Survey (NHIS), which has been conducted from 1968 to the present, to obtain smoking histories for the country. These data and data from the Tobacco Use Supplement to the Current Population Survey (TUS-CPS) are used to estimate smoking history parameters from 1993 to the present for each state.

A conceptual framework for smoking behavior is that at some point, an individual begins to use cigarettes and continues until the time that they quit. This is overly simplified because individuals develop their smoking habit over time, and quitting often takes several attempts before success. However, it broadly captures the essential features needed to describe the population's behavior. Surveys give information about the age when an individual begins to smoke, and this can be used to estimate the probability of initiation for each year of age. The initiation probability can also estimate smoking prevalence at each age, but individuals in the survey must have survived to that point. For older individuals, much time has passed since they started smoking, and during that time, some individuals in the cohort will have died.

The proportion of individuals who report ever having smoked changes as the cohort ages, due in part to the difference in mortality rates. It is necessary to adjust for this in the analysis so that the estimates are appropriately calibrated. Cessation probabilities at a

given age for individuals in a birth cohort are similarly estimated. Finally, the distribution of smoking levels is estimated for each age group in the birth cohorts.

The algorithm for developing smoking histories

The algorithm for developing smoking histories in a population is efficient and has been used to characterize various subsets of the population in the U.S. To accurately describe trends, it is essential to have a sufficiently long follow-up period. NHIS has been conducted since 1968, so we now have over 50 years of data to estimate trends. This has provided good estimates for the whole of the U.S. NHIS has not been well designed for an analysis that breaks down the population by state, which TUS-CPS more strongly covers. Unfortunately, the latter only started collecting data in 1993, thus providing only thirty years of follow-up. This shorter span makes it more challenging to estimate time trends, but an analysis that brings together these two surveys allows one to capture the strengths of each one, yielding smoking history trends for each state. [3] This approach has also been used to characterize other subgroups based on race, [4, 5] education, [6] and income. [7]

To estimate the effect of a tobacco intervention program, one can specify the magnitude of the impact on specific steps in the tobacco history for individuals in a cohort. To illustrate, consider the impact of tobacco control programs in the U.S. since the publication of the Surgeon General's Report in 1964. This report laid out what was known at the time about the effects of smoking on health. The parameters estimated by NHIS showed that smoking behavior changed after 1964 and that the effect on initiation and cessation was quantified. To assess the impact of that change, it was assumed that initiation and cessation probabilities remained at the high levels seen before 1964. By calculating the prevalence of cigarette smoking under the observed and the alternative scenarios, the prevalence of current, former, and never smokers was estimated, along with the length of time that individuals were smokers. These results were then used to estimate death rates under each scenario, the number of premature deaths avoided, and years of life saved. In the 50 years following the publication of the Surgeon General's Report, more than 8 million premature deaths were avoided, and 157 million years of life were saved. [8]

Public health interventions impact on behavioral factors

To quantify the impact of public health interventions on behavioral factors affecting health, like cigarette smoking, it is essential to develop a modeling framework that characterizes that behavior over an individual's life. The CISNET team developed the smoking history generator, and it provides a way to estimate the health impact resulting from modifications to initiation, cessation, and smoking intensity. The approach has also been used to study population subgroups, considering geographical areas, racial or ethnic groups, or social characteristics. Different interventions can be more effective in each subgroup so that one can determine the most effective strategy for disease control.

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Biostatistics in the Yale University School of Public Health
Here we explore Theodore Holford's work in Biostatistics in the Yale University School of Public Health and his current research into how lung cancer is affected by cigarette smoking.