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SPECIAL ARTICLE

Using the Past to Understand the Future of U.S. and Global Smoking Disparities: A Birth Cohort Perspective

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U.S. smoking-related disparities persist, but data evaluating how smoking patterns across diverse populations have changed by birth cohort are lacking. Worldwide, smoking continues to exact harm, especially to low- and middle-income nations with less historical data for smoking analyses. The Cancer Intervention and Surveillance Modeling Network Lung Working Group previously generated smoking histories for the whole U.S. population using an age, period, and birth cohort methodologic framework. These inputs have been used in numerous models to simulate future patterns of smoking and to evaluate the potential impact of policies. However, the absence of detailed model-ready inputs on smoking behaviors for diverse U.S. populations has been a barrier to research evaluating future trends in smoking-related disparities or the projected impacts of policies across sociodemographic groups. This supplement issue provides new estimates of smoking behaviors with detailed historical data by race/ethnicity, by educational attainment, by family income, and for each of the 50 U.S. states and Washington, District of Columbia. All-cause mortality RRs associated with smoking by race/ethnicity and educational attainment are also available for the first time. Finally, the supplement issue presents comprehensive smoking histories for Brazil, showing the application of this methodology to resource-limited settings. Collectively, these data aim to offer insight into future U.S. and global smoking disparities and accelerate research on tobacco control policies that advance health equity. This effort will allow tobacco simulation models to account comprehensively for population diversity, thereby enabling researchers to develop more sophisticated analyses of tobacco use and control interventions.

A BRIEF HISTORY

Since the publication of the first Surgeon General's Report on Smoking and Health in 1964,[1] the U.S. has benefited from major improvements to health and life expectancy, partly owing to decades of progress in tobacco prevention and control that drastically reduced smoking and consequently smoking-related morbidity and mortality in the population.[2] Social norms around smoking changed dramatically over this time period; as Americans grew to understand the harms of smoking and secondhand smoke exposure, many quit and quit in droves, and many fewer young people started to smoke.[1]

As public health progress unfolded, differences in how communities experienced that progress came to light, and in 1998, Surgeon General's Report on smoking disparities was published, "Tobacco Use among U.S. Racial/Ethnic Minority Groups," focused on 4 groups: African Americans, American Indians and Alaska Natives, Asian Americans and Pacific Islanders, and Hispanics.[3] Since then, research examining smoking disparities has proliferated, expanding beyond race/ethnicity to encompass disparities by SES, geographic region, and other sociodemographic characteristics or comorbid health conditions.[4–6] From 2000 to 2022, 1,306 articles related to smoking disparities have been indexed through PubMed (Query: [Smoking (MeSH Major Topic)] AND [Disparities]).

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Research related to smoking disparities was synthesized in a 2017 National Cancer Institute Tobacco Control Monograph detailing how smoking disparities have been shaped by multiple factors at the individual, interpersonal, community, and societal levels across the life course.[4] At the societal level, tobacco control interventions such as tobacco taxation, smoke-free air laws, and access to smoking cessation treatment improved public health, but low SES and racial/ethnic minority groups were less likely to benefit.[4] Meanwhile, sophisticated tobacco industry marketing campaigns contributed directly to disparities by targeting women, racial/ethnic minorities, homeless people, and other vulnerable groups.[7–13]

Beyond the U.S., global context also matters: both the WHO Framework Convention on Tobacco Control and international trade agreements have shaped tobacco policies across different countries.[14–18]

In the U.S., public health authorities have continued to emphasize the importance of understanding smoking disparities and achieving health equity goals for racial/ethnic minorities. American Indian and Alaska Natives have the highest smoking rates of any racial/ethnic group, individuals of low SES continue to bear the brunt of tobacco-related disease and death,[19] and differences by state have been magnified by the slow adoption of tobacco control policies in the South and Midwest.[20] Although targeted tobacco control interventions have been developed to address smoking disparities,[21] including 'Tips from Former Smokers' campaigns tailored for racial/ethnic minorities and other priority populations,[22,23] their long-term impact on smoking disparities will need to be evaluated. How sociodemographic differences in cigarette smoking will unfold over the coming decades will depend on accurate information about smoking within and across populations and whether that information is used to inform policy and regulation.

A COHORT LENS

Cohort analyses are particularly crucial to understanding the smoking trajectories in U.S. populations. As each birth cohort comes of age, they face their own unique sociocultural and policy environments during key life stages relevant to smoking uptake (adolescence, young adulthood) and cessation (middle and older ages). For instance, an individual born in 1975 was surrounded by a different tobacco product and policy landscape and a different set of social norms surrounding smoking as a teenager during the 1990s from someone born in 1960 who would have been at peak smoking initiation ages during the 1970s and 1980s. Major events, policies, and social changes have defined the lives and influenced the behaviors of entire birth cohorts during the most significant ages of smoking initiation and cessation. Examples are disruptions caused by the 20th century's 2 world wars, during which cigarettes were provided to American soldiers as rations, inducing higher smoking initiation in certain birth cohorts[24]; college education subsidies provided by the G.I. Bill to military veterans improved social mobility and decreased smoking among veterans who used them[25]; and the women's liberation movement whose feminist slogans were co-opted by Philip Morris to market Virginia Slim cigarettes to young women.[12] In more recent history, the National Truth campaign, launched in 2000 as a smoking prevention educational campaign, reduced smoking initiation among adolescents born in the 1980s.[26] Without a cohort lens, researchers may attribute changes in smoking patterns to contemporaneous issues of a given period rather than acknowledging the impact of shifts in the lived experiences of different generations.

To understand how public health interventions (or lack thereof) are impacting the smoking behaviors of newer generations, it is necessary to examine and compare changes by birth cohort or generation (e.g., people born in the 2000s versus people born in the 1980s). Researchers have studied smoking trajectories by birth cohort for the U.S. population (Figure 1),[27,28] but the cohort perspective has been relatively absent from the smoking disparities literature. This literature has mostly documented trends in cross-sectional prevalence by period (calendar year), but such analyses combine information from multiple birth cohorts into a single metric, usually age-adjusted or crude prevalence, thereby masking trends as they vary across generations within specific subpopulations. Examining changes in prevalence and potential disparities by birth cohort, within advantaged and disadvantaged groups, offers a more accurate assessment. In addition, trend analyses of a specific subpopulation (e.g., people of low SES) by period implicitly assume homogeneity across birth cohorts. Therefore, disaggregating the population by birth cohort provides a more comprehensive view—one that better reflects societal changes.

For instance, much larger proportions of recent generations have completed college degrees than those born earlier, reflecting the integration of women and racial/ethnic minorities in higher education institutions as well as changing expectations for future employment.[29] Thus, the 1950 birth cohort of people with a college education has a substantially different demographic profile from that of the 1990 birth cohort with college degrees. Because college education is often completed earlier in life, this characteristic is then carried forward, affecting the educational mix in future years.

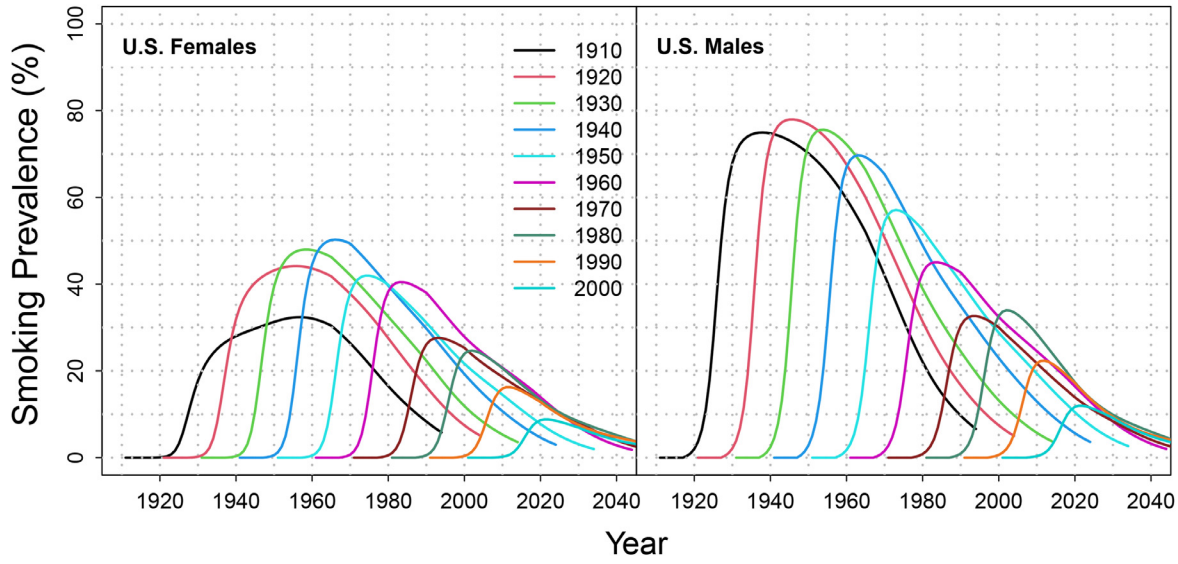

Figure 1. Smoking prevalence by birth cohort for the U.S. population.
Note: Lines represent individual birth cohorts from 1910 (black line, farthest to left) to 2000 (teal line, farthest to right). Data reflect increasing smoking prevalence among females from 1910 to 1940 birth cohorts and declines from 1950 to 2000 birth cohorts; among males, smoking prevalence increased from the 1910 to 1920 birth cohorts, with declines in most subsequent cohorts. Estimates of current smoking prevalence by cohort and gender were generated by the CISNET Lung Working Group using the APC methodologic framework.[27,28]
APC, age, period, and birth cohort; CISNET, Cancer Intervention and Surveillance Modeling Network.

Other broader demographic developments over time, such as patterns of immigration,[30] combined with differences in birth rates[31] mean that among U.S. births, larger shares have come from Hispanic women, reflecting the rising proportion of Hispanics in the overall population. This translates into recent birth cohorts being more comprised Hispanics than older birth cohorts.[32] Therefore, the cohort perspective facilitates trend analysis of smoking by sociodemographic groups that may be changing in size and composition.

MOVING BEYOND SMOKING PREVALENCE

Most reports analyze data and trends in smoking prevalence—the main metric used to evaluate smoking progress in the population and the primary point of comparison between advantaged and disadvantaged groups. However, overall smoking prevalence is a function of multiple underlying drivers at the individual level. To reconstruct individual-level smoking histories across the population, information is needed regarding who started smoking (ever use) and when (initiation), who is smoking now (current use), how long people who smoke continue to do so (duration), the intensity with which they smoke (cigarettes per day), and who quit (former use) and when (cessation). These behavioral components represent different points for intervention and metrics of progress and collectively shape disparities in smoking prevalence across populations and across time and age. For example, similar overall smoking prevalence estimates for White and Black Americans may mask key differences: Black Americans start smoking at older ages than Whites but have less success with quitting.[33] Therefore, Black Americans tend to have longer smoking duration and thus a higher risk of lung cancer.[33–36] Black Americans are more susceptible to lung cancer than other racial/ethnic groups, even though they smoke fewer cigarettes per day[37]; as a result, Black Americans are less eligible for lung cancer screening (on the basis of calculated pack-years) than White Americans.[34,38–42] These findings contributed to the recent 2021 recommendation by the U.S. Preventive Services Task Force to extend lung cancer screening eligibility to people who have smoked fewer pack years.[43] A comprehensive analysis of historical smoking patterns and behaviors within each key U.S. subpopulation can better inform future health equity efforts to help target policy or treatment interventions for specific groups by age, gender, and sociodemographic factors (i.e., race/ethnicity, SES).

APPLYING THE AGE-PERIOD-BIRTH COHORT FRAMEWORK

The Cancer Intervention and Surveillance Modeling Network (CISNET) Lung Working Group has

previously constructed age, period, and birth cohort (APC) models for the whole U.S. population's smoking history using data from the 1965–2018 National Health Interview Surveys.[27,28] These analyses generated estimates of the distribution of individual-level parameters for smoking initiation; cigarettes smoked per day; and smoking cessation by age, gender, and birth cohort, starting with the generation born in 1890. Collectively, these parameters are validated by reproducing observed trends in smoking prevalence in the U.S. population. These estimates are internally consistent, forming a comprehensive picture of the smoking experience for specific groups. For example, Figure 1 presents smoking prevalence by birth cohort for the entire U.S. population generated by the CISNET Lung Working Group.

The APC approach can be applied across different sociodemographic groups, thereby facilitating comparisons of smoking patterns across groups accounting for age, period, and cohort differences. This process allows historical comparisons of the specific smoking metrics by race/ethnicity, SES, and geographic location, thereby providing a more complete picture of the components affecting past and present smoking disparities. Research in this arena could help to further develop strategies that aim to achieve tobacco and health equity but have yet to achieve their full potential.

LEVERAGING HISTORICAL DATA TO MODEL THE FUTURE

The CISNET smoking history parameters are age and cohort specific and the statistical distribution of individual-level inputs that have been leveraged to make projections about future smoking trends for the population as a whole (Figure 2). They are widely used as inputs for simulation models of tobacco use, tobacco control policy, and lung cancer screening for the U.S. population.[27,44–49] These models have been used to evaluate the potential impact of tobacco policies on smoking and lung cancer,[27,46,48,50–52] the benefits and harms of different lung cancer screening strategies,[38,53–55] their effectiveness and cost effectiveness,[45,56–58] as well as the effect of smoking cessation in lung cancer screening settings.[59,60] Tobacco simulation models are useful tools for surveillance and policy evaluation; recent analyses have begun to apply such models for analyzing and predicting changes

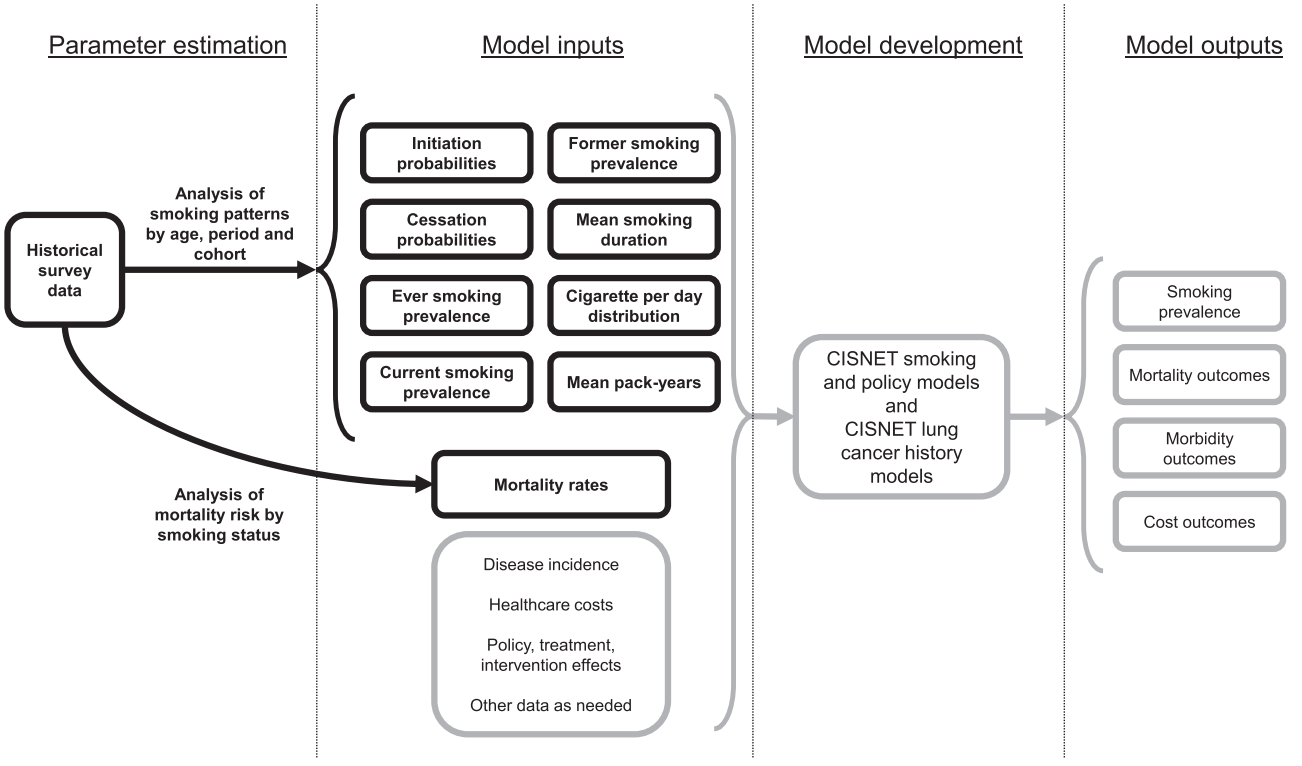

Figure 2. The CISNET Lung Working Group approach to modeling smoking, smoking-related mortality, and lung cancer.
Note: Black lines with text in bold typeface represent research and data published in this supplement. Age, period, and cohort analyses were conducted for the U.S. population by race/ethnicity, education, income, and state and for the Brazilian population. Mortality analyses were conducted for the U.S. population by race/ethnicity and education only.
CISNET, Cancer Intervention and Surveillance Modeling Network.

in smoking disparities by race, income, and mental health status.[4,49,61,62] However, models are only as reliable as the smoking inputs applied, and the lack of detailed empirical data inputs for specific subpopulations, developed in a systematic and consistent way, has limited the development of modeling and evaluation tools to monitor progress toward health equity aims. Moreover, these tools require mortality inputs that reflect differences by smoking status for specific populations; although RR estimates for mortality by smoking status are available for the general U.S. population,[63–65] the lack of such estimates for different sociodemographic groups is also an impediment to health equity research progress.

This supplement presents the most detailed and comprehensive historical analysis of U.S. smoking patterns and disparities to date. Using decades of data from the National Health Interview Surveys and a rigorously validated APC methodology, the CISNET Lung Working Group examines the smoking histories for specific U.S. subpopulations as they vary by race/ethnicity, family income, level of educational attainment, and state of residence. As the data become more sparse, the methodologic issues become more challenging. Figure 3 presents applications of the APC methodology in previously published studies and their extensions to new sociodemographic groups analyzed within this supplement issue. Five of the papers in this supplement issue cover U.S. populations: 4 examining smoking histories for specific subpopulations (Figure 3) and a fifth paper examining mortality associated with smoking by age, gender, race/ethnicity, and education.

Throughout these papers, the authors refer to harms caused by smoking commercial cigarettes and not sacred tobacco used for traditional or ceremonial Indigenous practices.[66] The term gender is used to refer to males (men/boys) and females (women/girls), consistent with recommendations that sex be used to refer to biological factors and gender for social factors such as smoking.[67] Other genders are not considered because survey measures have historically treated gender as binary.

Race/Ethnicity

Analysis of Meza et al.[68] of smoking patterns by race/ethnicity presents a major advance: historical smoking histories by age, gender, and birth cohort for American Indian and Alaska Natives—the group that bears the largest burden of health harms caused by cigarette smoking—at the national level. For the first time, smoking parameters are also available for the Hispanic, non-Hispanic White, non-Hispanic Black, and Asian and Pacific Islander populations.

Education

Analyses of Cao and colleagues[69] of smoking-related disparities by SES generally affirm an inverse relationship between the level of education—a major component of SES—and smoking outcomes, where less educated individuals have higher smoking prevalence, whereas more educated individuals have lower prevalence. However, their analyses of changing birth cohort smoking patterns by level of educational attainment reveal novel

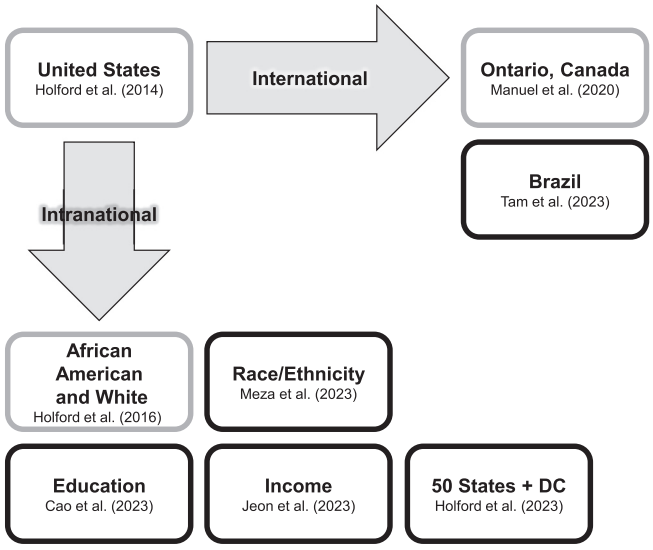

Figure 3. Extensions of the APC framework for population smoking histories.
Note: Gray outlines represent previously published applications of the APC framework for smoking histories. Black outlines represent APC extensions to new populations published in this supplement.
APC, age, period, and birth cohort; DC, District of Columbia.

findings among those with the lowest levels of education in the U.S.

Income

Trends in smoking disparities by level of family or household income—another important determinant of individual SES—are challenging to analyze owing to data missingness, the variety of income sources within a household, and poverty thresholds being contingent on family structures.[70] Analysis of Jeon et al.[71] was therefore quite the methodologic undertaking. The authors addressed well-known income data challenges to impute missing income data. The result is an extensive historical analysis of smoking behaviors across U.S. birth cohorts as they vary by poverty status going back to 1983.

States

Local and state researchers and policymakers will now benefit from detailed state-specific smoking parameters published in this supplement issue by Holford and colleagues.[72] The authors generated comprehensive smoking histories for each of the 50 U.S. states and the District of Columbia. Now rich, detailed historical information reflects each state's unique smoking trajectories as shaped by the societal and policy norms of their populations.

Mortality Risk

Parameters for smoking behaviors alone are not sufficient to conduct modeling analyses for disparate groups; mortality risk estimates are also necessary (Figure 2). The mortality analysis of Jeon et al.[73] begins to fill this gap: the paper presents detailed RR of mortality estimates by race/ethnicity (Hispanic, non-Hispanic Black, and non-Hispanic White) and education according to smoking status. The Jeon and colleagues[73] mortality analysis, together with the smoking parameters provided by Meza et al.[68] and Cao and colleagues,[69] respectively, now offer a full suite of data to inform modeling, evaluation, and surveillance tools for specific race/ethnicity and education groups. Future analyses of smoking-specific mortality risk estimates by state and family income could provide similar opportunities.

MOVING THE AGE-PERIOD-BIRTH COHORT FRAMEWORK BEYOND U.S. BORDERS

The APC methodology has been successfully extended to numerous U.S. subpopulations, accounting for wide-ranging social, demographic, and geographic diversity across the country and its implications for smoking. Manuel et al.[74] have successfully adapted the APC framework to produce smoking histories for the population of Ontario, Canada using biennial cross-sectional data from 2003 to 2013. Although far fewer data points are available for this modeling, it would be remiss not to extend this methodology to other countries, especially low- and middle-income nations that are disproportionately impacted by the global burden of smoking. In Latin America, ~70 million people smoke, which translates into substantial harm to public health. Brazil has made progress toward reducing smoking, but as the most populous nation in Latin America, its lower overall prevalence still reflects over 20 million[75] people who smoke in this country. This supplement issue provides the first extensions of the APC methodology to Brazil (Figure 3).

Brazil

The CISNET Lung Working Group and experts at the Brazilian National Cancer Institute (Instituto Nacional de Câncer José Alencar Gomes da Silva) estimated detailed smoking histories of the Brazilian population for birth cohorts from 1950 to 2000. With fewer historical data points available from the National Household Sample Survey and National Health Surveys, Tam and colleagues adapted the APC approach for Brazil.[76] The work shows the feasibility of adapting this rigorous validated methodology to a resource-limited setting, indicating that similar studies could be developed in other countries with limited data.

Looking Ahead

The U.S. studies consider race/ethnicity, education, income, and state independently, but future smoking parameters could be estimated to evaluate intersectional populations, such as racial/ethnic groups by SES. As well, the smoking parameters generated for the Brazilian population could be further extended to consider differences within the country by region, race/ethnicity, or SES. Moreover, similar analyses are being conducted to derive estimates for 2 more Latin American countries: Mexico and Argentina. The present set of studies should not be viewed as comprehensive; they merely offer a beginning.

Progress toward health equity aims has been inadequate—hampered in part by the lack of critical information needed to understand smoking behaviors within specific populations. This supplement issue aims to accelerate tobacco control progress and scale up research on tobacco-related health disparities and their resulting impacts on marginalized populations. The data generated in this supplement issue are publicly available for users to examine and download through an interactive website at https://apps.cisnetsmokingparameters.org/. The data can be used to make projections about future

smoking within specific subpopulations under different assumptions for baseline or status quo conditions or under policies that impact only smoking initiation (e.g., Tobacco 21 laws[52]), only cessation,[60] or both.[77] Researchers can also use the data to evaluate changes in smoking disparities between groups over time and to assess the relative impacts of different policy interventions on population health.

Promising research evaluating policies as they impact tobacco use disparities for diverse populations is already being published.[78–89] There are now opportunities for researchers to combine the smoking parameters produced in this supplement issue with emerging research on the impacts of tobacco policies or regulations for specific vulnerable subgroups. Future surveillance and policy modeling to explicitly study historically marginalized populations—largely excluded from such scholarship—are sorely needed. Finally, the application of APC approaches to other countries and subpopulations should facilitate analyses of historical smoking patterns and the development of context-specific models. These, in turn, can inform the development of local policies aimed at reducing not only smoking-related morbidity and mortality but also reducing smoking-related disparities globally.

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