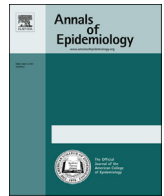




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The role of epidemiology in evidence-based policy making: a case study of tobacco use in youth

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ABSTRACT

Purpose: Sound public health policy is based on relevant and timely information. A brief review of the history of youth tobacco control illustrates the central role of epidemiology to inform policy choices and evaluate their consequences.

Methods: A narrative review was conducted.

Results: Epidemiologic studies have shown that most smokers begin as adolescents or young adults and individuals who reach their mid-20s as nonsmokers are unlikely to ever become smokers. This key recognition made it clear that long-term tobacco control must prevent initiation of smoking among youth. Over time, tobacco use prevention interventions have evolved, increasing in reach and effectiveness as they moved from initially focusing on the individual to an approach that targets both populations and communities. Effective interventions for preventing youth smoking include raising tobacco prices, clean indoor air laws, and intensive mass media campaigns.

Conclusions: Great strides have been made in youth tobacco control but 18% of high-school students continue to smoke. It is up to epidemiologists, fellow scientists, practitioners, and advocates to assure that strategies that are known to work are fully implemented and to continue to find more successful solutions that can further lower the incidence of youth smoking initiation and can address new tobacco products and changing contexts.

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Introduction

Sound public health policy is based on relevant and timely information. The data often involve quantitative evidence that can take many forms, ranging from scientific information in peer-reviewed journals, to the evaluations of individual programs or policies [1]. Evidence-based policies are based on systematic and objective assessments of the science including meta-analyses,

decision analyses, and economic evaluations [2,3]. Both epidemiology and other scientific disciplines have much to contribute. In particular, the theoretical and qualitative methods of the social sciences enrich and broaden scientific knowledge, increase recognition of the importance of context, and generate frameworks and questions suitable for quantitative studies and analyses. Even when the methodology is rigorous and appropriate, the scientific evidence that is generated is but one component that informs policy decisions. Lomas describes three components of social decision making: (1) scientific evidence or information that is knowable and which is true regardless of context, (2) social science evidence or information that is, knowable but dependent on context, and (3) colloquial or idiosyncratic information. This information can only be combined within a deliberative process [4]. Policy decision makers must provide feasible and acceptable policies, while also meeting budgetary and legal constraints. Given the complex

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Table 1
Key roles of epidemiology in evidence-based policy

Policy need	Role
Problem	Define and understand the problem
Population	Determine which populations are high risk
Intervention	Ascertain which interventions lead to better health outcomes and among which populations
Institutionalize programs and policies	Inform programmatic or policy decisions including scaling up effective programs, and policies. Evaluate the impact of programs or policies. Conduct quality assurance and improvement. Continue to iteratively refine and improve approaches by adding new interventions or replacing less effective ones with more effective options.

decision-making environment, the science must be strong, communicated effectively, and timely. Indeed, policy decision makers nearly always need to act in the face of uncertainty because evidence is sparse, lacking in quality, or both. It is incumbent on epidemiologists to help policy makers understand that uncertainty and not be paralyzed by it.

We briefly describe the history of youth tobacco control in the United States and illustrate the central role of epidemiology to inform policy choices and evaluate the consequences. It is a prime example of “consequential epidemiology”—using epidemiology to drive change and make a meaningful difference in health outcomes [5]. The following sections use tobacco control among youth to illustrate how epidemiology and the related sciences have helped us understand the problem, assess the effectiveness of interventions, inform policy and programmatic decisions, and evaluate progress (Table 1). As our knowledge has increased, interventions for reducing tobacco use among youth have evolved in an iterative process. Epidemiology has been central to our recognition that smoking largely begins among youth, preventing smoking initiation is critical to controlling tobacco use, and policies are the most effective interventions.

Epidemiology of tobacco use in youth

By most measures, the epidemiology of tobacco use among youth has changed for the better over the past 50 years. The prevalence of current smoking among youth is lower than it has been in decades (6.6% for aged 12–17 year), and the rate of quitting smoking in younger birth cohorts has been increasing [6]. Nonetheless, tobacco use among youth remains a public health problem of substantial importance due to adolescence being the time when most smokers start, emerging tobacco products, the burden of disease attributable to tobacco, and disparities in tobacco use.

Eighty-seven percent of adult smokers begin smoking before the age of 18 years [7] and 98% begin before the age of 26 years [6]. The fact that smoking initiation typically happens during adolescence has been historically encouraged by tobacco industry marketing that has effectively targeted youth [8–12]. Nearly one in three young adults is a current smoker and smokeless tobacco is increasing in use, particularly among white high-school males [7]. This has both immediate and long-term adverse health effects, including the development of chronic diseases; yet, in spite of progress in reducing tobacco use since the 1960s, tobacco use remains the single largest preventable cause of death and disease in the United States [13].

National surveys reveal that there are significant racial and gender differences in smoking among adolescents. Specifically, American Indian/Alaska Natives have the highest prevalence of cigarette smoking, followed by white and Hispanic adolescents and young adults and then Asian and African American youth. In addition, whites and Hispanics are more likely than African Americans to be current or daily smokers throughout adolescence [14–18] and also appear to initiate smoking earlier [19,20]. Moreover, more males than females smoke [14]. There are policies, such as increasing the price of cigarettes through taxation, that decrease

youth cigarette consumption (which is especially effective among low-income populations) [21]; however, relatively few data exist to ascertain whether youth subgroups may respond differently to effective smoking programs or policies. An understanding of the gender, race/ethnicity, and socioeconomic level differences in cigarette use among youth will likely shed additional light on how to curb its initiation and escalation during adolescence and young adulthood [22]. A nuanced insight on tobacco use epidemiology can be used to prioritize problems, identify critical gaps and barriers, and inform selection and use of interventions.

Historical background of youth smoking policies and programs

The first Surgeon General's report on smoking [23] devoted little space to the issue of youth smoking but did review evidence for current theories as to why people initiate smoking. This 1964 report noted the period from the early teens to age of 20 years as the part of the lifespan when most eventual smokers started using cigarettes. At the time, the research pointed to factors such as socioeconomic status, parents' smoking habits, and gaining status among peers as reasons why youth begin to smoke, but no particular interventions, programs, or policies targeted at youth were recommended. As a result of this initial Surgeon General's report, there was momentum to act on the problem of youth smoking. In the following decade, for the first time, there was a movement to implement antismoking programs for youth in schools. These programs often featured a focus on the consequences of smoking and were delivered in classrooms, peer-to-peer, or through school assemblies [24]. However, success was limited as documented in a 1978 review of 35 studies that reported only minimal effects [25]. Beginning in the late 1970s, social influence for tobacco prevention education came into vogue. The goal of the social influence approach was to teach youth to reject social pressures that might push them to initiate tobacco use [24]. This was typically accomplished in classroom-based programs where students would be instructed, often through a variety of strategies including peer education, role-playing, and small group discussion in behavioral skills to resist social pressures to smoke [26].

In 1994, 30 years after the initial Surgeon General's report, the first report focusing on youth was published [27]. By then, the United States had seen dramatic reductions in the prevalence of smoking among adults; however, the problem of youth smoking was proving to be more difficult. The report's foreword stated that 28% of high-school seniors reported being current smokers [27] and the report detailed a comprehensive list of determinants of youth smoking such as parental smoking, social support for smoking, socioeconomic status, and psychological well-being. Public health efforts successfully deployed by schools and communities to counteract cigarette uptake were described in the report. These included school-based programs that taught skills to reduce social influences, increased cigarette prices through tax policy, and enforced age-of-sale laws for cigarettes [27].

The 1994 Surgeon General's Report echoed a larger paradigm shift in thinking about the youth smoking issue that occurred in the early 1990s. Instead of focusing on individuals, the target of youth

smoking prevention campaigns became populations and communities. Policy was the ideal intervention vehicle. The American Stop Smoking Intervention Study for Cancer Prevention (ASSIST), which launched in 1991, was an exemplar of this approach. Funded by the National Cancer Institute, several state health departments in partnership with the American Cancer Society changed economic, social, and cultural environmental factors in their states to discourage youth from smoking. This was in part motivated by the accumulation of epidemiologic (etiologic) evidence and a greater recognition that secondhand smoke was dangerous to nonsmokers [28–30]. In addition to reframing the issue as a societal problem rather than an individual problem, the community approach had a wider reach, provided “consistent and inescapable” antitobacco cues, and integrated tobacco-free norms into community institutions [30]. ASSIST focused on four areas of policy, all of which were relevant to youth: (1) elimination of environmental tobacco smoke in public places, (2) reduced advertising and promotion of tobacco, (3) decreased youth access, and (4) increased taxes. By the time ASSIST ended in 1999, ASSIST states saw a small statistically significant reduction in adult smoking prevalence compared with non-ASSIST states, a reduction that was important at the population level (ASSIST did not measure youth smoking) [31]. Not surprisingly, this effective population-based approach that ASSIST played a large role in kick starting was seen as a major threat by the tobacco industry. The tobacco industry devised a strategy to outflank the wave of evidence-based tobacco policies. This tobacco industry effort included gaining congressional allies, promoting laws that preempted stricter local clean indoor air laws that would further restrict tobacco use in public spaces, and encouraging the diversion of funds from ASSIST’s community and environmental channel [31]. Their message to the public was that ASSIST was a waste of taxpayer dollars, placed an unfair burden on the poor, and was a conspiracy of the “left” and the left’s allies (academics and nonprofits) to outlaw a legal product [32].

Evaluation of interventions

The assessment of tobacco-related outcomes is a critical part of the process of evidence-based policy making. The findings from evaluations of tobacco control efforts are summarized in numerous authoritative documents including the reports of the US Surgeon General and the best practices summaries from Centers for Disease Control and Prevention [33]. In this section, we briefly describe several core concepts for assessing the impact of tobacco control policies among youth.

Evaluation offers evidence regarding the need for, and the quality and effectiveness of, a range of interventions aimed at preventing tobacco use. It can offer a multitude of benefits to public health practitioners and policy experts including (1) assessment of the distribution of the problem and need for intervention; (2) course-correcting information—interventions that may not fit or may not be effective in the local circumstances of their application; (3) monitoring of interventions, a source of quality assurance on how well those responsible for implementing programs or enforcing policies are performing their functions, and (4) long-term surveillance to assess whether the intervention is achieving its intended outcome or impact (Table 1).

Measurement is often accomplished via public health surveillance, that is, the ongoing systematic collection, analysis, and interpretation of outcome-specific health data [34]. In the United States, we have excellent epidemiologic data for estimating which population groups and geographic regions of the country are affected and how patterns are changing over time with respect to tobacco use. Numerous surveillance systems allow progress in addressing tobacco use among youth to be tracked at state and local levels (Boxes 1 and 2 for two illustrative state examples). Although

Box 1. California case study

California is often seen as a bellwether. Successful efforts to control tobacco began in the 1970s with Yolo County forbidding smoking in public parks and a 1970 law in Berkeley requiring restaurants to provide a nonsmoking section. A 1978 attempt at passing a statewide clean indoor air law failed in the face of strong industry-supported opposition. A breakthrough occurred with the passage of a San Francisco Workplace Smoking Initiative that required the accommodation of both smokers and nonsmokers and subsequently a similar law in Los Angeles requiring no smoking areas in most worksites. By 1986, the American Lung Association and the American Cancer Society embarked on a campaign to raise tobacco taxes and a survey showed that 73% of Californians favored an increase in the cigarette tax of 25–35 cents with the money allocated for cancer research and prevention (resulting in the Proposition 99 ballot initiative). In rapid succession, the California Department of Health Services went smoke free and the governor signed a senate bill banning smoking on in-state buses, trains, and airplanes (within months the Federal Aviation Administration banned smoking on all flights under 2 hours duration). Twenty percent of the increase in cigarette taxes was earmarked for health education against tobacco. Subsequent efforts established the California Tobacco Control program, tobacco research institutions, and tobacco control efforts in 61 local public health departments. By 1990, the cities of San Luis Obispo and Lodi had banned smoking in restaurants and bars and Sacramento became the first county to ban smoking in all worksites. Rates of tobacco smoking were falling in the face of major advertising campaigns targeting multiple groups and counter advertising by the industry. The 1990s saw the elimination of distribution of free tobacco samples, major changes in funding of the tobacco program, and a new ballot measure banning smoking in all restaurants and businesses in Sacramento County, a measure that went statewide in 1995. Although adult tobacco smoking had dropped by over 23%, teen smoking remained unchanged. Multiple new initiatives were implemented including lawsuits brought against the tobacco industry for manipulative promotion and to recover health care costs, greater enforcement of sales to minors, nationally-recognized anti-smoking advertisements, limitations on billboard advertising, and anticigar campaigns. The 1997 California Environmental Protection Agency report on the hazards of secondhand smoke energized additional initiatives [49]. An additional 50 cent tax on tobacco products was imposed with the money used to fund a program directed to children ages 0–5 years (first five). Further efforts to limit smoking on hospital campuses, beaches, multiunit dwellings, and other places continued. Retail vendors were forbidden to have self-service displays and enforcement against sales to minors was strengthened. An independent evaluation demonstrated a reduction in smoking with exposure to the California Tobacco Control Program and subsequently a reduction in lung cancer. These early and strong efforts have made tobacco smoking rates in California among the lowest in the nation. Although California was a pioneer in increasing tobacco taxes, tax rates have not kept up and remain relatively low compared with other states. Nonetheless, the investment in tobacco control has paid large dividends in terms of improved health. Although the state has achieved a great deal, more progress needs to be made (Fig. 1).

Box 2. Massachusetts case study

Significant strides in tobacco control and prevention have been made in the past 20 years in the state of Massachusetts. Policy makers, public health officials, and citizen alike joined forces to implement the Massachusetts Tobacco Cessation and Prevention Program (MTCP). The MTCP is an antitobacco program that is run by the Massachusetts Department of Public Health with four primary goals: (1) to prevent smoking in youth, (2) increase cessation rates among current smokers, (3) prevent exposure to secondhand smoke, and (4) eliminate tobacco-related disparities. The program has successfully lowered the overall per capita adult cigarette consumption and aided in the decline of both adult and youth smoking prevalence.

Efforts in tobacco control and prevention began in the state in 1992, when residents of Massachusetts voted to increase the state excise tax on cigarettes and allot a portion of the revenue to help fund the MTCP. The state successfully passed the Question One ballot initiative, which placed \$25 per pack tax on cigarettes and dedicated a portion of the revenue to the creation of the Massachusetts Tobacco Control Program. To date, the MTCP has since been able to help more than 33,000 MassHealth smokers quit, decrease smoking among high-school students by more than 60%, decrease the sales of cigarette packs by 4.6% annually, and reduce the number of heart attack deaths by 577 deaths each year. These achievements inspire the work of the MTCP and other states to follow suit.

By 1999, the state of Massachusetts passed a law committing all of Massachusetts's tobacco settlement revenues to public health and tobacco control programs, with more than \$22.8 million from tobacco settlement revenues going to tobacco control programs in fiscal year 2000. By 2004, citizen passed a law to make workplaces in the state of Massachusetts smoke free. This was followed shortly by the enactment of smoking cessation programs, redefining little cigars as cigarettes, and increasing tax on cigarettes, which further helped to fund the program and overall health reform. In the span of about 2 decades, this program became one of the leading public health initiatives in the United States.

Some of the policy achievements that have been implemented are:

- Massachusetts Legislature mandates coverage for tobacco use cessation for all MassHealth/Medicaid members (effective July 1, 2006)
- Massachusetts Legislature enacts a law that bans smoking in all indoor workplaces (2004)
- MTCP implements a toll-free information and complaint line to monitor the smoke-free workplace law (2004)
- Massachusetts Legislature increases the cigarette tax by 75 cents to \$1.51 per pack and collects an additional \$66 million in state revenue (2002)
- Massachusetts is the second state to require cigar label warnings prompting a national cigar label (1999)
- Massachusetts is the first state to require disclosure of cigarette additives and a more accurate method for reporting nicotine yield (1996)
- Massachusetts is the first state to divest state pension funds of tobacco stock (1995)

(continued)

(continued)

- Massachusetts is the fifth state to sue for smoking-related Medicaid costs (1994)
- Massachusetts is the first state to require warnings on smokeless tobacco products prompting enactment of a federal law requiring the same (1985)

These policies, informed by epidemiology, have led to significant progress in Massachusetts with regard to tobacco prevention and control (Fig. 2).

epidemiologic data exist for estimating which population groups and which regions of the country are affected by tobacco use and how prevalence patterns are changing over time, new information is addressing environmental and policy surveillance. These data present information on a broad array of environmental (e.g., the density of outlets selling tobacco products) and policy factors (e.g., state laws and local ordinances) that describe these patterns and provide a better understanding of surveillance data.

Effective interventions for youth include raising tobacco prices, smoke-free air laws, and intensive mass media campaigns. These have been extensively studied and have been central in driving progress to reduce smoking. Effectiveness is not the only issue to be considered in selecting and using interventions. Information on the burden and cost of illness attributable to tobacco in particular populations or geographic areas is also important for demonstrating need for and selecting particular interventions. Modeling is a useful tool to quantify these issues. For example, Smoking-Attributable Mortality, Morbidity, and Economic Costs is an online application that can be used to estimate the health and health-related economic consequences of smoking (<http://apps.nccd.cdc.gov/sammec/>). Smoking-Attributable Mortality, Morbidity, and Economic Costs results supported several state lawsuits against tobacco companies, which were pursued to recoup some of the tobacco-related costs in states. These lawsuits contributed to settlements in Mississippi, Florida, Minnesota, and Texas, and ultimately to the nationwide Master Settlement Agreement. The Master Settlement Agreement between the remaining 46 states and the District of Columbia and the tobacco industry included payments by the tobacco industry to these states with the intent of reimbursing states for Medicaid costs related to tobacco use and prevention of youth smoking [35].

Tobacco control policy continues to add new tools to its arsenal. For example, in 2009, the Family Smoking Prevention and Tobacco Control Act Public Law No. 111-31 gave the Food and Drug Administration new abilities to regulate tobacco products such as bans on flavored cigarettes, intended to help combat youth smoking. As new approaches to tobacco control are added, and as context changes, both new and more established approaches will need

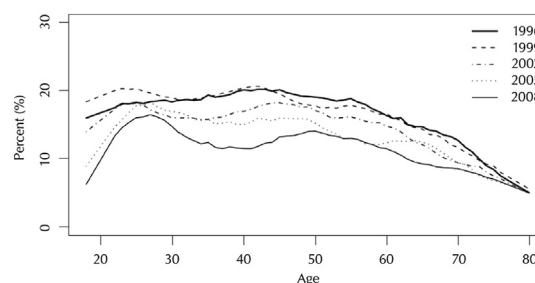


Fig. 1. Age-specific prevalence of tobacco use in California, 1996–2008. http://www.cdph.ca.gov/programs/tobacco/Documents/Resources/Publications/CDPH_CTS2008%20summary%20report_final.pdf (accessed September 23, 2013).

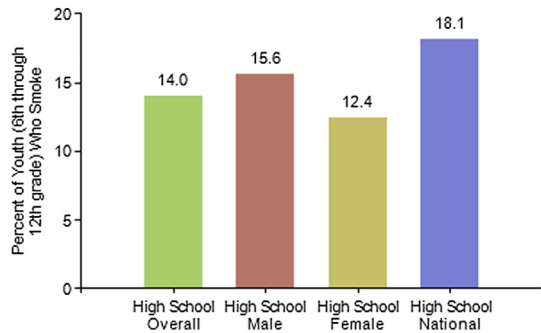


Fig. 2. Massachusetts' state smoking prevalence among youth, 2011. Source: Youth Risk Behavior Surveillance System 2011, and <http://apps.nccd.cdc.gov/statesystem/HighlightReport/HighlightReport.aspx> (accessed September 25, 2013).

continued evaluation to assure that they are achieving their objectives. The introduction of e-cigarettes and the rapid increase in their use is a current example of the continuing challenge of control of smoking-related products [6,36].

Conclusion and lessons learned

The 50-year journey from the first Surgeon General's report identifying smoking as a leading cause of premature death to the present day has been a singular lesson in our understanding of risk and how to reduce it. The evolution from interventions focused on individuals to structuring environments where people live has fundamentally changed our conception of tobacco control. The transition of public health activities based largely on education and individual behavior to embrace a broader ecologic model capitalizes on clinical, educational, environmental, social, and policy interventions whose synergies have reduced tobacco use among youth substantially. We describe insights about how epidemiology and related sciences have informed policy efforts related to tobacco use reduction among adolescents and young adults.

Follow the scientific evidence

Many public health and health care efforts have been undertaken to explicitly place practice and policy recommendations within scientific evidence [37–40]. Although efforts to establish recommendations grounded in scientific evidence should enhance credibility and transparency of the resulting tobacco policy recommendations, they are not simple one-size-fits-all solutions and need to be tailored. No single study design or evidence hierarchy is useful in all situations [41]. Epidemiology has a broad range of study designs and analytic approaches in its tool chest and the tools used for collecting and synthesizing evidence must be appropriate and feasible for the question being asked.

Interventions must be tested and evidence summarized

As interventions are implemented, they must be tested. Epidemiology, statistics, and other disciplines have helped to improve the confidence with which individual studies and bodies of evidence support conclusions about whether interventions lead to changes in outcomes. These approaches typically involve using epidemiologic criteria for strengthening conclusions about causal inferences, an early exemplar of which is the 1964 Surgeon General's report on smoking and health [23]. Many examples have also been applied to evaluating interventions in both the medical [42] and social sciences [43]. Good quality summaries of the scientific evidence for

system, policy, and environmental approaches in youth tobacco control exist for both clinical [40,44] and community interventions [7,38] and can be found in Surgeon General reports [45] and the Community Guide [38]. These two resources nicely illustrate the strengths and weaknesses of the main approaches to reviewing scientific evidence (narrative and systematic reviews). Narrative reviews such as Surgeon General reports provide panoramic and detailed overviews of a topic, whereas systematic reviews complement narrative reviews by explicitly limiting potential biases in how studies are identified, interpreted, and synthesized as well as providing better information on effect sizes [46]. In addition, all public health action will not be based on current high-quality scientific evidence. Resources like CDC's best practices allow scaled coordinated action in the absence of robust evidence, approaches that can then be tested.

Enact policies and programs relevant to youth and engage multiple stakeholders

Epidemiologic studies have shown that most smokers begin as adolescents or young adults and if they were nonsmokers through their mid-20s, they were unlikely to become smokers. This key recognition made it clear that long-term tobacco control must prevent initiation of smoking among youth. This recognition called for more information about effective interventions in this target age group. Social scientists who had been studying youth contributed critical insights into their motivations, behaviors, and social norms and suggested interventions to affect them. Economists studied their sensitivity to the price of cigarettes. Lawyers helped formulate, enact, and implement policies and regulations. Economic modelers forecast the impacts of programs and policies. New information, often filtered through the media, empowered advocacy groups, deflected misleading claims from industry [47], and strengthened the will of policy makers. What emerged was a concerted effort to change the environments around smokers. The range of interventions included clean indoor air laws banning smoking from schools, workplaces, and other public places, increases in tobacco taxes, laws regulating promotion of tobacco products, and counter-advertising. Success begot new questions, new studies, new interventions, new evaluations, and new programs, establishing an iterative process where studies facilitated adoption and implementation of programs and policies and those interventions presented new natural experiments and new opportunities to learn. Along the way, less effective approaches gave way to more effective ones.

Turn the tables on acceptable behavior

A greater understanding of the drivers of smoking led to innovative interventions. As those interventions were found to be effective, communities began adopting them. A virtuous cycle began. What was initially perceived to be a "right" to smoke transformed into a "right" to be unexposed to harmful tobacco. Acceptance of smoking as a norm became unacceptable. Epidemiologists and evaluators showed the effectiveness and synergies of these interventions and over time social norms have changed dramatically.

In summary, great strides have been made yet the battle is far from won. High-school students smoke at half the rate they did 15 years ago, but 18% of students continue to smoke [48]. It is up to epidemiologists, fellow scientists, practitioners, and advocates to assure that strategies that are known to work are fully implemented and to continue to find more successful solutions that can further lower the incidence of youth smoking. Interventions, no matter how effective and well documented, cannot achieve their

promise if not fully implemented. Even for tobacco, where an enormous amount is known about effective community intervention, much work is left to be done [6]. We can take pride in our progress, but the need for better smoking interventions remains.

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