Original Investigation

Did youth smoking behaviors change before and after the shutdown of Minnesota Youth Tobacco Prevention Initiative?

Nina L. Alesci, Jean L. Forster, & Darin J. Erickson

Abstract

Introduction: No previous studies document the effects of both comprehensive tobacco control and its defunding on youth smoking. This study tests the effect of the youth-focused Minnesota Youth Tobacco Prevention Initiative (MYTPI) and its shutdown on youth smoking and determines whether these effects differed by age.

Methods: The Minnesota Adolescent Community Cohort is a population-based, observational study designed to evaluate the MYTPI. The sample included cohorts of youth aged 12–16 years at baseline in Minnesota ($N=3,636$) and a comparison group in six other Midwestern states ($n=605$). Biannual surveys assessed youth smoking from October 2000, 5 months after the MYTPI launch, through October 2005, 2 years postshutdown. Adjusted piecewise linear trajectories predicted smoking stage (measured on a 1–6 continuum) comparing Minnesota with a comparison group during the MYTPI (Slope 1) and postshutdown (Slope 2) for each baseline age cohort. Analysis then compared baseline age cohorts with each other by centering their intercepts on age 16.

Results: Neither slope of smoking stage differed between Minnesota and comparison groups, showing no period effects for the MYTPI or shutdown. However, younger cohorts, with early teen experience of MYTPI, smoked less than older cohorts by the same age. Mean smoking stage at age 16 differed by almost a half stage from the youngest (2.04) to the oldest (2.46) age cohort.

Discussion: The study offers no evidence of period effects for the MYTPI or its shutdown. Design limitations, national or continued post-MYTPI statewide tobacco control efforts, or program flaws could explain the findings.

Introduction

National trends in youth smoking prevalence indicate increases during the early 1990s followed by dramatic declines starting in the mid-1990s; however, these declines slowed to a halt in 2005 (Centers for Disease Control and Prevention [CDC], 2008; Johnston, O'Malley, Bachman, & Schulenberg, 2008). The rise of many statewide comprehensive tobacco control (CTC) programs followed by their subsequent loss of funding may provide one explanation for this pattern.

Statewide CTC is a best practice for reducing tobacco use (CDC, 2006, 2007; Institute of Medicine (U.S.), 2007). CTC aims to (a) prevent youth from starting to smoke, (b) help current smokers quit, (c) protect all from exposure to secondhand smoke, and (d) eliminate disparities among high-risk groups. CTC uses a multilevel approach consistent with the social ecological theory. Specifically, the CTC model intervention aims to change the social environments or the nested interpersonal, organizational, community, and state settings that make the complex behavior of tobacco use normal (Richard, Potvin, Kishchuk, Prlic, & Green, 1996; Sallis & Owen, 2002). Truly comprehensive programs target both youth and adults with a mix of educational and policy strategies. Both the evidence-based guidelines and the theory encourage policies, which lead to permanent and more far-reaching social environmental change (Rose, 1985), as the ideal strategy.

Since the first CTC program started in California in 1988, Massachusetts, Arizona, Oregon, and Maine have all funded CTC through increases in tobacco taxes. Mississippi, Florida, Texas, and Minnesota funded programs with settlement dollars from individual lawsuits against the tobacco industry. An additional 38 states initially allocated a portion of their dollars from the national Master Settlement Agreement (MSA) to statewide

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tobacco control (U.S. Department of Health and Human Services, 2000). Despite the demonstrated results in reducing tobacco use (Kuiper, Nelson, & Schooley, 2005), many CTC programs, including those of California, Massachusetts, Florida, and Minnesota, have faced major budget cuts or elimination.

Very few peer-reviewed studies document the effect of major CTC funding cuts on the achieved tobacco use reductions. Pierce et al. (1998) modeled the effect of the 1993 40% budget cut to the California program using piecewise linear spline regression on repeated cross-sectional data. Between 1989 and 1993, California cigarette consumption dropped from 9.7 to 6.5 annual packs per capita and adult smoking prevalence dropped from 23.3% to 18.0%, with both rates of decline exceeding the rest of the United States. From 1993 to 1996, after the budget cut, the annual rate of decline in cigarette consumption attenuated and the rate of decline in prevalence flattened. Other California studies similarly found decreases in rates of decline for both packs per capita consumption (Glantz, 1993) and heart disease mortality (Fichtenberg & Glantz, 2000) after the funding cut.

Two studies showed the effect of CTC funding cuts on youth smoking susceptibility and intention but not actual smoking behaviors. In Minnesota, youth susceptibility, or the self-reported potential to smoke in the next year, jumped from 43.3% to 52.9% after the 2003 elimination of the media campaign (and the entire youth-focused CTC program; CDC, 2004). In Florida, the rate of increase in intentions not to smoke among youth dropped in the year after elimination of that state's youth-focused CTC program (Niederdeppe, Farrelly, Hersey, & Davis, 2008).

Only one peer-reviewed study documented the effect of major CTC funding cuts on self-reported youth smoking behavior. This Oregon study, however, captured only the elimination of the school-based component, rather than the 70% funding cut to the entire statewide CTC program in 2003. The longitudinal cohort design showed that 30-day smoking prevalence increased more slowly among student cohorts exposed to the fully funded school programs compared with student cohorts in the same schools after the elimination and in schools that never had programs (Pizacani et al., 2009).

A few evaluations of entire statewide programs have demonstrated that these CTC programs exert their greatest influence on reducing initiation and 30-day prevalence among younger, middle school (rather than older, high school) age groups (Bauer, Johnson, Hopkins, & Brooks, 2000; Kuiper et al., 2005; Pierce, White, & Gilpin, 2005; Soldz, Clark, Stewart, Celebucki, & Klein Walker, 2002). In fact, the aging of never-smokers (i.e., noninitiators) created a cohort effect that led to the decline in 30-day smoking prevalence among all 12- to 17-year-olds 7 years after the California program began (Chen, Li, Unger, Liu, & Johnson, 2003). Young adults (18- to 24-year-olds) exposed as teens were also less likely to have experimented with cigarettes than older cohorts, suggesting an enduring effect (Pierce et al., 2005). Except for the Oregon study (Pizacani et al., 2009), most prior studies use repeated cross-sections. Such a multiyear cohort design of an entire statewide program could strengthen these findings by capturing the process of smoking onset within the same exposed group of youth (Wilcox, 2003).

Minnesota's 1998 settlement with the tobacco industry funded the Minnesota Youth Tobacco Prevention Initiative (MYTPI), which the Minnesota Department of Health (MDH) created and managed. Between January 2000 and July 2004, the state dedicated \$18 million during the first 18 months and an average of \$16 million for each following year (excluding administration and evaluation costs; MDH, 2001, 2002, 2003, 2005b) to focus exclusively on preventing smoking among 12- to 17-year-olds. Through statewide programs and local grants, the MYTPI engaged public and private partners to implement a mix of CDC-recommended activities, including (a) a statewide counter-marketing campaign, (b) policy action, (c) school-based prevention, and (d) nonpolicy-related community mobilization (McDonald & Ho, 2002; Starr, Rogers, Schooley, Wiesen, & Jamison, 2005). Similar to Florida and Arizona, Minnesota purposely selected CTC components that primarily reach youth rather than adults. Such youth-focused CTC falls short of true comprehensiveness as recommended by CDC (1999) *Best Practices*. Political choices, often driven by tobacco industry lobbying, tend to compel this youth focus (Siegel, 2002).

As part of a state budget shortfall solution, the legislature drastically cut MYTPI funding in 2003. With a 75% reduction to \$3.7 million annually, MDH completely eliminated both the state grants and the statewide counter-marketing campaign. The remaining tobacco control program primarily encouraged local policy action to pass ordinances creating smoke-free public places and community mobilization to encourage voluntary bans (MDH, 2005b).

The Minnesota Adolescent Community Cohort (MACC) study was designed to evaluate the MYTPI. The study followed five age cohorts of Minnesota youth starting at ages 12–16 years since 2000. In addition to studying the effect of the MYTPI, the 2003 shutdown provided an unplanned opportunity for the MACC study to test the effect of a major cut in tobacco control funding. The current analysis tested whether the MYTPI reduced smoking among youth after 3 years of exposure and if the near elimination of the program reversed that progress.

Methods

The MACC study uses a multilevel, population-based observational cohort with comparison group design. The multistage sampling design required first selecting 60 Minnesota geopolitical units (GPUs) or communities. From each GPU, the study used modified random digit dial sampling to identify households with at least one teen in the target age range within the target GPU. Among these households, respondents were selected at random from age quota cells that were still open for that GPU, following the same calling protocol for every member of the household-level sample. From each of the 60 GPUs, the study recruited 12 youths from five strata ages: 12, 13, 14, 15, and 16 years (i.e., 720 per age stratum; $N = 3,636$). Using the same techniques, the study also sampled a comparison group ($N = 605$) of the same age strata from the Kansas City nonmetropolitan area (39.8%, primarily in Kansas), the Kansas City metropolitan area (30.4%, primarily in Missouri), North Dakota (9.9%) and South Dakota (9.9%) combined, and the upper peninsula of Michigan (9.9%). These states shared similar demographic, geographic,

and cultural patterns as Minnesota but had not allocated MSA funds to tobacco control by the 2000 sampling period.

Clearwater Research conducted the recruiting and the telephone surveys. To reach MACC sample size goals in the Minnesota and comparison samples, Clearwater Research called 225,064 phone numbers resulting in 7,251 households known to be eligible by virtue of having an appropriate-age youth. Of these, 4,241 participated in baseline interviews, for a baseline response rate among eligible households of 58.5% (pooled between Minnesota and comparison samples because of their similarity). While less than 40% of parents refused to permit their child's participation, their demographics were similar to the participants, suggesting that the MACC sample did not systematically differ from the population.

Respondents completed telephone surveys every 6 months, except for the seventh wave (October 2003 through March 2004), which was not conducted due to a lapse in study funding. The current analysis used data collected from October 2000 (5 months after the MYTPI launch) through October 2005, that is, from the start of the MYTPI to 2 years after the MYTPI shutdown. The survey protocol required obtaining both parent consent and youth assent for each wave of data collection for respondents under age 18. Respondents received a \$10 check for each completed interview. The study continued to follow participants who moved out of a MACC GPU if they had stayed in the cohort at least up to the third wave of data collection, thus having at least 1 year of exposure to MYTPI. After 10 waves, the study retained nearly 80% of respondents from both the Minnesota (79.59%) and comparison (78.51%) cohorts. The University of Minnesota Institutional Review Board approved all methods.

Measures

Outcomes. The primary outcome variable, smoking stage, describes the process of youth initiation and progression from the least to most advanced stages of tobacco use. Treated as both a continuous and ordered categorical variable in analysis, it assigns respondents a one to six value based on the following mutually exclusive definitions: (a) *Never-smokers* have not smoked even a puff in their lifetime; (b) *Triers* have puffed but have not smoked more than one whole cigarette; (c) *Noncurrent experimenters/former smokers* have smoked more than one whole cigarette but none in the last 30 days, having either progressed beyond trying or having quit from more advanced smoking stages; (d) *Current experimenters* have smoked on 1–20 of the last 30 days but not in the last 7 days; (e) *Regular smokers* have smoked on 1–20 of the last 30 days and in the last 7 days; and (f) *Established smokers* have smoked on greater than 20 of the last 30 days. Respondents who did not answer enough questions to validly assign a stage or who skipped the entire wave were assigned as missing. Individual values for this outcome can fluctuate up and down with each data collection wave, although youth who have reached either Stage 2 or Stage 3 can never return to earlier stages. This variable roughly adapts the stages of smoking onset described in a comprehensive review (Mayhew, Flay, & Mott, 2000). A prior study has used a similar stage variable as an outcome in latent curve models (Simons-Morton, Chen, Abrams, & Haynie, 2004).

The second outcome, 30-day smoking prevalence, is the most common definition of youth tobacco use in surveillance and evaluation. This dichotomous variable defines *smokers*

as those who reported having smoked on at least one of the last 30 days, thus including those who smoke weekly and daily. *Nonsmokers* reported smoking on zero of the last 30 days. Respondents who answered “don't know” or “refused” or who skipped the wave were assigned as missing. Individual values can change with each data collection wave.

Independent variables. Age at baseline was used as a stratification variable. These groups signify the age when youth began exposure to the MYTPI.

By comparing individual-level time-invariant covariates, descriptive analysis determined baseline differences in the Minnesota and comparison cohorts that may confound their comparison. Demographics include gender, race (White vs. non-White), and spending money available in an average week (\$10 or less vs. \$11 or more) as an indicator of purchasing power and college plans after high school (yes, no) as a youth-level proxy for education. Other potential confounders related to smoking include (a) the baseline level of smoking initiation in the population, that is, whether respondents have ever smoked a whole cigarette (*ever-smokers*) at baseline or not (*never-smokers*) and (b) whether or not respondents lived with a parent, sibling, or other person that smokes cigarettes at baseline. All variables were dichotomous; respondents who answered “don't know” or “refused” were assigned as missing.

Descriptive analysis also monitored states' per pack cigarette tax and tested its relationship to smoking stage and 30-day smoking prevalence. At each wave, youth were assigned the current tax for their state at baseline regardless if they had moved. States that increased their excise taxes included Kansas (\$.46 in 2002 and \$.09 in 2003), Michigan (\$.50 in 2002 and \$.75 in 2004), and South Dakota (\$.20 in 2003; Orzechowski & Walker, 2007). Differences in this statewide policy, which can greatly influence youth smoking (Hopkins et al., 2001), could confound the relationship between exposure to the MYTPI and youth smoking.

Statistical analysis

After descriptive analyses to examine the data distribution and outliers, piecewise latent growth curve analysis modeled change in smoking stage and 30-day smoking prevalence from 2000 to 2005 among individual youth. These longitudinal models of repeated measures describe the mean trajectory of within-individual change over time for the entire group, determine if between-individual differences exist among the trajectories, and test for potential predictors of these different between-individual trajectories (Bollen & Curran, 2006). Latent growth curves use structural equation modeling to create the intercept (i.e., baseline value of the outcome) and slope (i.e., amount of change in the outcome per unit of time) as latent, or indirect, measures of between-individual variability. Unlike regular growth curve modeling, piecewise models link two linear splines at a node, or bend, testing for change in the slope of youth smoking behavior over two or more time periods (Bollen & Curran, 2006). The approach modeled the shutdown of the MYTPI in 2003 as a fixed transition point for the latent slope factor that is shared by all observations.

Specifically, analysis tested a measurement model of one intercept (α) and two slopes, one before (β_1) and one after (β_2) the

2003 MYTPI shutdown. The first slope (β_1) gives rise to the repeated measures (y) up to the shutdown. The second slope (β_2) gives rise to the repeated measures (y) after the shutdown. The fixed transition point was Wave 8, which was collected between April and September 2004. An annual time metric was the assigned factor loading for the slopes, signified as 0–4.5 for semiannually collected survey data, so that the coefficient for each slope describes the amount of linear change that would occur over a 1-year period.

Conditional models examined the influence of the shutdown between the Minnesota and comparison cohorts. Regression coefficients estimated the relationships between intervention status and latent intercept and slopes (Ullman, 2001). Models were stratified by each of the five baseline age cohorts to control for cohort effects. Models also adjusted for potential confounding by baseline demographics and presence of smoker in household as well as time-varying cigarette tax per pack. Centering analysis was not possible for models of stage as an ordered categorical outcome and 30-day smoking prevalence because the categorical models automatically fix all intercepts at zero.

To test whether baseline age cohorts differed in their smoking stage trajectories, unconditional analyses compared intercepts by centering each group on the common age of 16. Centering provides the same model and associated fit statistics but changes the interpretation of the intercept from the mean stage at baseline (i.e., wave one for all cohorts) to the mean stage at age 16 (i.e., the different wave corresponding with age 16 for each cohort; B. O. Muthen, 2004).

Because the intraclass correlation for smoking stage at each wave ranged from .00 to .02 and the design effect was below 2.0, analysis did not adjust *SEs* to account for the nested sampling design (Duncan, Duncan, & Strycker, 2006; B. O. Muthen & Satorra, 1995). All analyses were conducted using *Mplus* version 4.21 (L. K. Muthen & Muthen, 2006) using $p < .05$ as the cutoff for significance. In all models, missing data, although sparse, were accounted for using the maximum likelihood estimator (Schafer & Graham, 2002). In particular, growth curve models of stage as an ordered categorical outcome and binary 30-day smoking prevalence employed the “categorical” option with the default of delta parameterization to accommodate these distributions. These models also specified maximum likelihood with first-order derivatives and a conventional chi-square statistic to approximate *SEs* to estimate parameters.

Results

At baseline, the Minnesota cohort closely resembled the same-age population of Minnesota youth on gender, age, and race as measured in the 2000 census (data not shown). The Minnesota and comparison groups, overall (Table 1) and stratified by baseline age cohort, did not differ at baseline on levels of average smoking stage, 30-day smoking prevalence, proportion ever smoking a cigarette, and proportion living with a smoker. The groups also did not differ by demographic characteristics, except that the overall Minnesota cohort (14.8%) included fewer non-White respondents than the comparison cohort (17.9%; $p = .05$). For an inconsistent few specific baseline age cohorts, Minnesota and comparison groups differed on spending money, college

Table 1. Demographics and baseline smoking characteristics for Minnesota and comparison cohorts

	Minnesota cohorts (<i>N</i> = 3,636)	Comparison cohorts (<i>N</i> = 605)	<i>p</i> value
Baseline smoking characteristics			
<i>M</i> (<i>SD</i>) smoking stage at baseline	1.68 (1.27)	1.62 (1.11)	.25
30-Day smoking prevalence at baseline	9.9%	8.0%	.13
Ever smoked a whole cigarette at baseline	18.7%	17.1%	.33
Lives with a smoker in household	42.6%	40.2%	.28
Demographics			
Female	50.8%	49.8%	.64
White	85.2%	82.2%	.05*
Can spend \$10 or less in an average week	53.0%	56.6%	.11
Plans to attend college after high school	86.3%	86.5%	.88
Region			
Rural/small city	51.3%	–	
Suburban	35.2%	–	
Urban	13.5%	–	

Note. Region breakouts were not available for the comparison cohorts.

*Minnesota and comparison cohorts statistically differ at $p < .05$.

plans, and living with a smoker at baseline ($p < .05$; data not shown). No consistent relationships emerged between tax per pack of cigarettes and either smoking stage or 30-day smoking prevalence in bivariate correlations and *t* tests, respectively.

Conditional statistical models tested for the intervention effect by including a covariate for Minnesota intervention or comparison group status. These models adjusted for possible confounding by baseline race (White/non-White), plans to attend college, \$10 or more spending money per week, presence of a smoker in the household, as well as time-varying tax per pack of cigarettes.

No models of either the continuous stage (Figure 1) or the 30-day prevalence (not in figure) outcomes found significant differences between the Minnesota and comparison cohorts for the intercept (baseline), the first piecewise slope (during MYTPI), or the second piecewise slope (after MYTPI) for smoking stage outcomes regardless of baseline age cohort. (Models representing stage as an ordered categorical outcome produced the same results; therefore, this article presents the simpler continuous models, which can be displayed graphically.)

Smoking among younger baseline age cohorts appeared to increase more slowly during the MYTPI and more rapidly after its shutdown compared with the older baseline age cohorts. This finding occurred among both Minnesota and comparison cohorts (Figure 1). These differences, of course, may merely be the result of maturation differences.

Youth smoking behavior change before and after the shutdown of MYTPI

Figure 1. Piecewise growth curve models comparing mean smoking stage between Minnesota and comparison youth stratified by baseline age cohort. Models are adjusted for baseline race (White/non-White), college plans, \$10 or more spending money per week, presence of a smoker in household, and time-varying tax per pack of cigarettes. Lines are not straight due to adjustment for time-varying covariate.

The comparison of baseline age cohorts while holding age constant isolates actual differences between cohorts' growth curves from maturation effects.

Centering the intercept for the stratified piecewise models for continuous smoking stage on the common age of 16 determines if each baseline age cohort experienced different outcomes at the same age given differing amounts of MYTPI exposure by that age. The intercept comparison presumes potential differences result from differing slopes for the baseline age cohorts when at the same ages but does not directly compare their slopes (impossible with study data). Within the Minnesota sample, the mean smoking stage in the baseline 12-year-old cohort with 3 years of MYTPI exposure was 2.04 (95% CI = 1.92–2.15) by age 16. This mean intercept is less than the mean of 2.30 (95% CI = 2.18–2.41) for the baseline 14-year-old cohort with only 2 years exposure by age 16 and less than the mean of 2.46 (95% CI = 2.33–2.59) for the baseline 16-year-old cohort with no exposure (Table 2). Within the comparison sample,

intercepts centered on age 16 for baseline 12 year-olds similarly differed from most of the older cohorts (data not shown).

Discussion

As the first observational cohort of an entire statewide youth-focused CTC program and its subsequent shutdown, the MACC study explored the effect of the major state policy decision to implement and remove a social ecological intervention on youth smoking. This study addressed three key research questions, using piecewise latent growth curve models for two different outcomes with a hypothesized fixed transition point between the 2000–2003 MYTPI intervention and its 2003–2005 postshutdown phase.

Did youth smoking decrease during the MYTPI? A period effect occurs when a sudden, unusual exposure over a short timeframe influences an outcome. If the MYTPI had had its hypothesized period effect, the first piecewise slope for the Minnesota cohorts would have been flatter, indicating a slower increase in smoking stage and 30-day smoking prevalence, than the slope for the comparison cohorts. Instead, the regression coefficients measuring the difference in the first slope between the groups did not differ for any of the five age cohorts, suggesting no during-MYTPI period effect.

Did youth smoking increase after the MYTPI shutdown? If the MYTPI shutdown had had its hypothesized period effect, the second piecewise slope for the Minnesota cohorts would have increased to converge with the slope for the comparison cohorts. That is, without the program, Minnesota youth smoking would have increased to match comparison youth. The regression coefficients did indicate no difference in the second slope between Minnesota and comparison groups for either outcome. The hypothesized post-MYTPI effect, however, is contingent on the presence of a during-MYTPI effect. The lack of effect observed during MYTPI itself indicates that postshutdown slopes never differed, rather than suggesting that a post-MYTPI period effect caused

Table 2. Intercept values from piecewise models centering the intercept on age 16 (Minnesota cohorts)

Baseline age cohort	Stage at age 16	95% CI ^a
Baseline 12-year-old cohort	2.04	1.92–2.15 (a)
Baseline 13-year-old cohort ^b	2.18	2.07–2.30 (ab)
Baseline 14-year-old cohort	2.30	2.18–2.41 (bc)
Baseline 15-year-old cohort	2.24	2.13–2.35 (abc)
Baseline 16-year-old cohort	2.46	2.33–2.59 (c)

Note. ^aRows with no matching letters in parentheses are significantly different from each other. Rows with at least one matching alphabet in parentheses are not different.

^bThe baseline 13-year-old cohort was centered on age 16.5 due to lapse in data collection.

them to converge. The latent growth curve analysis isolated these hypothesized period effects from two sources of bias. First, *age effects* result from the natural development of youth as they initiate and progress to more advanced stages of, or increased, tobacco use as they grow older (U.S. Department of Health and Human Services, 1994). Age effects would occur in the absence of the MYTPI or its shutdown. Comparing the magnitude of increase in smoking stage slopes between Minnesota and comparison groups, rather than comparing two point estimates over time, controls for this bias. Second, *cohort effects* occur when members of a group share characteristics that may be associated with a certain outcome. The hypothesized larger effect of the MYTPI and its shutdown on younger compared with older age groups could have caused a cohort effect. Stratifying by baseline age cohort controlled for this source of bias by allowing each to follow a differently shaped growth curve in response to the MYTPI and its shutdown.

Did age cohorts differ in their response to the MYTPI and its shutdown? The centering analysis tested for, rather than controlled for, a cohort effect comparing younger with older baseline age cohorts. Given their greater exposure to MYTPI during a more influential development phase, the study hypothesized that younger baseline age cohorts were expected to smoke less than older cohorts. In fact, upon reaching the common age of 16, the mean smoking stage for the baseline 12-year-old cohort was lower than both the baseline 14- and 16-year-old cohorts. By modeling the intercept at the same age, this analysis controlled for bias from age effects. This cohort effect, however, occurred in both the Minnesota and comparison groups and cannot be attributed specifically to the MYTPI.

Controlling for tax per pack of cigarettes did not influence the findings, potentially due to the lack of variability in tax across states and over time as well as to the small sample size from each comparison state.

In summary, the study found no period effects for the MYTPI and its shutdown when comparing Minnesota with comparison states. Still, a cohort effect occurred across the age groups within Minnesota. Younger baseline age cohorts, who experienced the MYTPI during more years of potential smoking initiation, smoked less than older baseline age cohorts upon reaching the same age with less experience of the MYTPI during their early teen years.

The longitudinal cohort design is a new method to study the effect of a statewide CTC program and funding cutoff. Prior studies of CTC (Bauer et al., 2000; Biener, Harris, & Hamilton, 2000; Pierce et al., 1998; Pierce et al., 2005; Soldz et al., 2002) and their shutdown (CDC, 2004; Niederdeppe et al., 2008) primarily compared repeated cross-sectional outcomes from different samples of the same aged population over time. In this study design, sampling variation may reduce sensitivity, especially when measuring prevalence once per year or less (Wakefield & Chaloupka, 2000). In contrast, the current study measured outcomes on the same youth before and after the removal of an intervention. Unlike cross-sectional designs, this longitudinal cohort design captures the possible within-individual fluctuation in smoking stage every 6 months over several years (Wilcox, 2003), a potentially more sensitive approach.

Several limitations prevent this study from firmly concluding that neither CTC programs, such as the MYTPI, nor their shutdown affect youth smoking. First, comparison states ide-

ally would have no tobacco control activity. Although MACC comparison states did not use MSA funds for tobacco control, since 2000, the American Legacy Foundation has aired the *truth* counter-marketing media campaign, provided grants for community-based organizing, developed youth activism, and implemented other activities for supporting adult cessation and reducing secondhand smoke exposure (American Legacy Foundation, 2008). Further, contamination of a \$16 million per year program across nearby state borders is plausible. Finally, the tobacco industry may have increased advertising in Minnesota relative to comparison states because of the MYTPI.

Second, to see a post-MYTPI shutdown effect, no other CTC activity should have occurred in Minnesota. Yet, in addition to MDH's much smaller remaining program, Blue Cross and Blue Shield of Minnesota and ClearWay MinnesotaSM funded more adult-focused CTC. These programs offered cessation services, organized for local smoke-free policies, and advocated for a tobacco tax increase since 2000 with the most intense effort during the postshutdown era. While not directed at youth, these efforts may have contributed to reductions in youth smoking during and even after the shutdown. Such declines in youth smoking were also observed in California (Chen et al., 2003; Pierce et al., 2005), where CTC did not focus only on youth but on social norms among the whole population (California Department of Health Services, 1998).

Third, secular trends rather than the CTC intervention may also explain the observed results. Minnesota's youth smoking prevalence had begun declining before 2000 (MDH, 2005a). Yet, the MYTPI and other Minnesota and national tobacco control activities—designed to change social environments—likely contributed to this secular trend.

Fourth, despite the advantages, the longitudinal cohort design does not test the population-level effect of social environmental exposures, like the MYTPI, as well as it captures individual-level change among a group receiving a specific intervention (Murray, 1998). The current study assumes that simply residing in Minnesota during program and its shutdown adequately captures the exposure. The key benefit of this exposure definition is its ability to capture the sum of the entire statewide program at the level of policy making in comparison to other states with no such program. The authors next plan to measure the increases in each specific aspect of CTC within Minnesota, that is, in local youth access and secondhand smoke policies, school-based activities, and community mobilization, during the MYTPI and shutdown period. Finally, analysis will link Minnesota youths' smoking outcomes to their individual exposure to these specific social environmental variables over time, thus better employing the longitudinal design.

Fifth, either the 3-year MYTPI program or its shutdown may have lacked the necessary time to influence youth smoking relative to comparison states. Increases in cumulative expenditures—particularly the initial expenditures—in statewide tobacco control have led to reductions in adult smoking prevalence (Farrelly, Pechacek, Thomas, & Nelson, 2008), pointing to the need for programs to have time to build capacity before realizing their full potential impact. Furthermore, the MYTPI or its shutdown could have affected intermediate outcomes not studied in this analysis, such as smoking attitudes, another important future direction for MYTPI evaluation with MACC data.

Finally, the MYTPI implementation did not fully follow CTC best practices. The CDC recommends that programs reach both adults and youth. The legislative mandate to focus on preventing smoking among only 12- to 17-year-old youth rather than all Minnesotans did help pass the bill creating the MYTPI. Yet, lack of attention to adults may have hindered the MYTPI's success. (Other organizations' adult-focused programs had only just begun from 2000 to 2003.) Theory and the CTC evidence base also recommend a strong policy component, in addition to educational strategies, in order to attain more far-reaching social environmental change. Beyond the highly visible youth-focused statewide counter-marketing campaign, the extent of such implementation is still unclear. Early evidence suggests that MYTPI offered less policy than educational strategies. The planned future analyses will reveal the adequacy of local policy and other evidence-based activities.

In the past several years, states have been curtailing CTC funding. The political will to continue these massive statewide interventions has been difficult to maintain, leading to funding cuts in several states. Consistent with prior literature, younger Minnesota adolescents, who experienced the MYTPI during more years of potential smoking initiation, smoked less than their older peers upon reaching the same age after a period of youth-focused CTC. The observation of a similar effect in comparison states does not allow making a causal link between these smoking declines and the MYTPI. Given that youth in both Minnesota and comparison states were exposed to tobacco control activity during this period, these findings may still support the CDC's desire to sustain the statewide CTC model. This study also did not find an immediate effect of a major youth-focused CTC program shutdown on youth smoking behavior.

These results still do not suggest that CTC should end. The MYTPI's potentially incomplete implementation of CTC's principles and the study's limitations point to the critical need for more studies of the effect of CTC and many funding cutoffs in other states—particularly of the more complete programs that also address adult cessation and exposure to secondhand smoke—not only on youth smoking but also on the intermediate outcomes that predict smoking.

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Declaration of Interests

The three authors of this article have no competing interests to report.

References

- American Legacy Foundation. (2008). *What we do*. Retrieved 1 September, 2008, from <http://www.americanlegacy.org/whatwedo.aspx>
- Bauer, U. E., Johnson, T. M., Hopkins, R. S., & Brooks, R. G. (2000). Changes in youth cigarette use and intentions following implementation of a tobacco control program: Findings from the Florida Youth Tobacco Survey, 1998–2000. *Journal of the American Medical Association*, 284, 723–728.
- Biener, L., Harris, J. E., & Hamilton, W. (2000). Impact of the Massachusetts tobacco control programme: Population based trend analysis. *British Medical Journal*, 321, 351–354.
- Bonnie, R. J., Stratton, K., & Wallace, R. B. (Eds.) (2007). *Ending the tobacco problem: A blueprint for the nation*. Washington, DC: National Academies Press.
- Bollen, K. A., & Curran, P. J. (2006). *Latent curve models: A structural equation perspective*. Hoboken, NJ: Wiley-Interscience.
- California Department of Health Services. (1998). *A model for change: The California experiment in tobacco control*. Sacramento: Tobacco Control Section, California Department of Health Services.
- Centers for Disease Control and Prevention. (1999). *Best practices for comprehensive tobacco control programs—August 1999* (Vol. reprinted, with corrections). Atlanta, GA: U.S. Department of Health and Human Services, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.
- Centers for Disease Control and Prevention. (2004). Effect of ending an antitobacco youth campaign on adolescent susceptibility to cigarette smoking—Minnesota, 2002–2003. *MMWR Morbidity and Mortality Weekly Report*, 53, 301–304.
- Centers for Disease Control and Prevention. (2006). *Targeting tobacco use: The nation's leading cause of death*. Retrieved 4 September 2006, from www.cdc.gov/nccdphp/publications/aag/osh.htm
- Centers for Disease Control and Prevention. (2007). *Best practices for comprehensive tobacco control programs—2007* (Vol. reprinted with corrections). Atlanta, GA: U.S. Department of Health and Human Services, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking or Health.
- Centers for Disease Control and Prevention. (2008). *Trends in the prevalence of tobacco use, National Youth Risk Behavior Surveillance Survey: 1991–2007*. Retrieved 21 June 2008, from www.cdc.gov/HealthyYouth/yrbs/pdf/yrbs07_us_tobacco_use_trend.pdf
- Chen, X., Li, G., Unger, J. B., Liu, X., & Johnson, C. A. (2003). Secular trends in adolescent never smoking from 1990 to 1999 in California: An age-period-cohort analysis. *American Journal of Public Health*, 93, 2099–2104.
- Duncan, T. E., Duncan, S. C., & Strycker, L. A. (2006). *An introduction to latent variable growth curve modeling: Concepts, issues and applications* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.
- Farrelly, M. C., Pechacek, T. F., Thomas, K. Y., & Nelson, D. (2008). The impact of tobacco control programs on adult smoking. *American Journal of Public Health*, 98, 304–309.
- Fichtenberg, C. M., & Glantz, S. A. (2000). Association of the California Tobacco Control Program with declines in cigarette

consumption and mortality from heart disease. *New England Journal of Medicine*, 343, 1772–1777.

Glantz, S. A. (1993). Changes in cigarette consumption, prices, and tobacco industry revenues associated with California's Proposition 99. *Tobacco Control*, 2, 311–314.

Hopkins, D. P., Briss, P. A., Ricard, C. J., Husten, C. G., Carande-Kulis, V. G., Fielding, J. E., et al. (2001). Reviews of evidence regarding interventions to reduce tobacco use and exposure to environmental tobacco smoke. *American Journal of Preventive Medicine*, 20(Suppl. 2), 16–66.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2008). *Monitoring the Future: National results on adolescent drug use: Overview of key findings, 2007*. Bethesda, MD: National Institutes of Health, National Institute on Drug Abuse.

Kuiper, N. M., Nelson, D. E., & Schooley, M. (2005). *Evidence of effectiveness: A summary of state tobacco control program evaluation literature*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Mayhew, K. P., Flay, B. R., & Mott, J. A. (2000). Stages in the development of adolescent smoking. *Drug and Alcohol Dependence*, 59(Suppl. 1), S61–S81.

McDonald, R. P., & Ho, M. H. (2002). Principles and practice in reporting structural equation analyses. *Psychological Methods*, 7, 64–82.

Minnesota Department of Health. (2001). *Tobacco use prevention and local public health endowment. Report to the Minnesota Legislature*. St. Paul: Minnesota Department of Health.

Minnesota Department of Health. (2002). *Tobacco use prevention and local public health endowment. Report to the Minnesota Legislature: 2001 activities*. St. Paul: Minnesota Department of Health.

Minnesota Department of Health. (2003). *Tobacco use prevention and local public health endowment. Report to the Minnesota Legislature: 2002 activities*. St. Paul: Minnesota Department of Health.

Minnesota Department of Health. (2005a). *Changes in tobacco use by Minnesota youth, 2000–2005: Results from the Minnesota Youth Tobacco Survey*. St. Paul: Minnesota Department of Health.

Minnesota Department of Health. (2005b). *Tobacco use prevention: Report to the legislature on 2003–2004 activities*. St. Paul: Minnesota Department of Health.

Murray, D. M. (1998). *Design and analysis of group-randomized trials*. New York: Oxford University Press.

Muthén, B. O. (2004). *Statistical analysis with latent variables, growth modeling*. Podcast Retrieved June 30, 2008, from <http://www.ats.ucla.edu/stat/seminars/ed231e/default.htm>

Muthén, B. O., & Satorra, A. (1995). Complex sample data in structural equation modeling. *Sociological Methodology*, 25, 267–316.

Muthén, L. K., & Muthén, B. O. (2006). *MPlus user's guide* (4th ed.). Los Angeles, CA: Muthén & Muthén.

Niederdeppe, J., Farrelly, M. C., Hersey, J. C., & Davis, K. C. (2008). Consequences of dramatic reductions in state tobacco control funds: Florida, 1998–2000. *Tobacco Control*, 17, 205–210.

Orzechowski, W., & Walker, R. C. (2007). *Tax burden on tobacco: Historical compilation, Volume 42*. Arlington, VA: Orzechowski & Walker.

Pierce, J. P., Gilpin, E. A., Emery, S. L., White, M. M., Rosbrook, B., Berry, C. C., et al. (1998). Has the California tobacco control program reduced smoking? *Journal of the American Medical Association*, 280, 893–899.

Pierce, J. P., White, M. M., & Gilpin, E. A. (2005). Adolescent smoking decline during California's tobacco control programme. *Tobacco Control*, 14, 207–212.

Pizacani, B. A., Dent, C. W., Maher, J. E., Rohde, K., Stark, M. J., Biglan, A., et al. (2009). Smoking patterns in Oregon youth: Effects of funding and defunding of a comprehensive state tobacco control program. *Journal of Adolescent Health*, 44, 229–236.

Richard, L., Potvin, L., Kishchuk, N., Prlic, H., & Green, L. W. (1996). Assessment of the integration of the ecological approach in health promotion programs. *American Journal of Health Promotion*, 10, 318–328.

Rose, G. (1985). Sick individuals and sick populations. *International Journal of Epidemiology*, 14, 32–38.

Sallis, J. F., & Owen, N. (2002). Ecological models of health behavior. In K. Glanz, B. K. Rimer, and F. M. Lewis (Eds.), *Health behavior and health education* (3rd ed., pp. 462–484). San Francisco, CA: John Wiley & Sons.

Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods*, 7, 147–177.

Siegel, M. (2002). The effectiveness of state-level tobacco control interventions: A review of program implementation and behavioral outcomes. *Annual Review of Public Health*, 23, 45–71.

Simons-Morton, B., Chen, R., Abroms, L., & Haynie, D. L. (2004). Latent growth curve analyses of peer and parent influences on smoking progression among early adolescents. *Health Psychology*, 23, 612–621.

Soldz, S., Clark, T. W., Stewart, E., Celebucki, C., & Klein Walker, D. (2002). Decreased youth tobacco use in Massachusetts 1996 to 1999: Evidence of tobacco control effectiveness. *Tobacco Control*, 11(Suppl. 2), ii14–ii19.

Starr, G., Rogers, T., Schooley, M., Wiesen, E., & Jamison, N. (2005). *Key outcome indicators for measuring comprehensive*

tobacco control programs. Atlanta, GA: Centers for Disease Control and Prevention.

Ullman, J. B. (2001). Structural equation modeling. In B. G. Tabachnick and L. S. Fidell (Eds.), *Using multivariate statistics* (4th ed., pp. 653–771). Needham Heights, MA: Allyn & Bacon.

U.S. Department of Health and Human Services. (1994). *Preventing tobacco use among young people: A report of the Surgeon General*. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

U.S. Department of Health and Human Services. (2000). *Reducing tobacco use: A report of the Surgeon General*. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Wakefield, M., & Chaloupka, F. J. (2000). Effectiveness of comprehensive tobacco control programmes in reducing teenage smoking in the USA. *Tobacco Control*, 9, 177–186.

Wilcox, P. (2003). An ecological approach to understanding youth smoking trajectories: Problems and prospects. *Addiction*, 98(Suppl. 1), 57–77.