

# Draft Status Report on the Massachusetts Tobacco Control Campaign, With a Preliminary Calculation of the Impact of the Campaign on Total Health Care Spending in Massachusetts

by Jeffrey E. Harris MD PhD<sup>1</sup>  
Massachusetts Institute of Technology and  
Massachusetts General Hospital  
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## INTRODUCTION

In November 1992, residents of Massachusetts approved a ballot petition that increased the excise tax on cigarettes beginning January 1, 1993, and asked legislature to spend the tax proceeds on tobacco control and health education. The Massachusetts Tobacco Control Program (MTCP), administered by the Massachusetts Department of Public Health (MDPH), was established in response to the voters' approval of the petition. In October 1993, MTCP initiated a statewide mass-media antismoking campaign. In early 1994, the Program began funding local boards of health and school health and other youth programs to promote policies to reduce public exposure to environmental tobacco smoke and to restrict youth access to cigarettes. The MTCP supported health education programs, primary-care providers, and other services to help smokers quit.

In a 1996 analysis of the effects of the Program,<sup>2</sup> I reported that the number of packs of cigarettes purchased per adult had declined by 20 percent in the Commonwealth between 1992 and 1996. By comparison, there was only a 6-percent decline in per capita consumption in the rest of the country during the same time period. The decline in per capita consumption could not be explained by increased cross-border purchases in New Hampshire. Moreover, the percentage of adults who described themselves as current smokers fell from 23.5 percent in the three years (1990–1992) prior to the implementation of the MTCP to 21.3 percent in the three years (1993–1995) immediately after implementation of the Campaign.

The present draft report updates the analysis of trends in cigarette smoking since the passage of Question 1. As shown in Figure 1 below, tax-paid cigarette consumption per adult has continued to decline. Per capita consumption for 1998

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<sup>1</sup> The contents of this report are the author's sole responsibility, and do not necessarily represent the views of the Massachusetts Institute of Technology, Massachusetts General Hospital, Massachusetts Department of Public Health, or any other organization. This draft status report reflects work in progress. I anticipate that a revised version will be submitted for publication.

<sup>2</sup> J.E. Harris, et al. Cigarette Smoking Before and After an Excise Tax Increase and an Antismoking Campaign -- Massachusetts, 1990-1996. *Morbidity and Mortality Weekly Report*. Volume 45, Number 44, November 8, 1996, pp. 996-970.

is down an estimated 30 percent from its pre-Question 1 level in 1992. As in my 1996 report, there continues to be little evidence that the decline in tax-paid per capita consumption in Massachusetts is simply a statistical artifact caused by increased cross-border traffic to New Hampshire.<sup>3</sup>

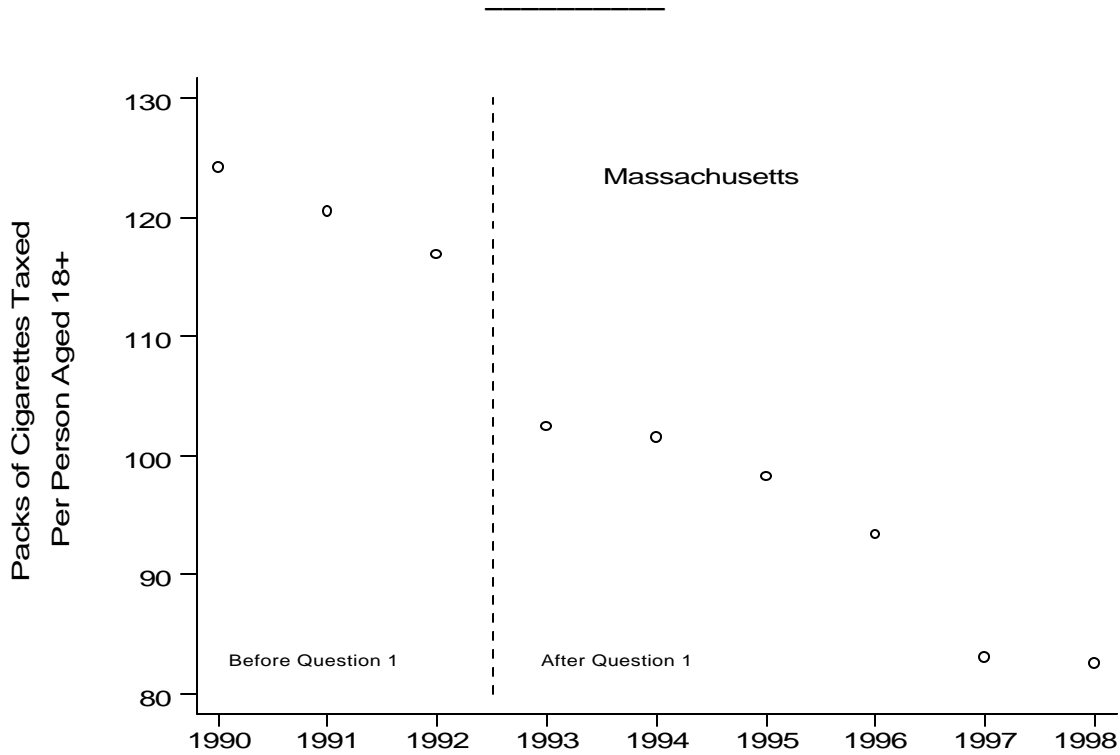


Figure 1. Trends in Tax-Paid Cigarette Consumption Per Adult. Massachusetts, 1990–1998.

Sources: Tobacco Institute; Massachusetts Department of Revenue; and U.S. Census Bureau.  
 Note: 1998 data based upon estimated shipments for November and December 1998.

My analysis here focuses on trends the prevalence of smoking, that is, the percentage of individuals who describe themselves as current cigarette smokers in

<sup>3</sup> During 1992 to 1998, the number of packages of cigarettes taxed in New Hampshire rose by 31 million. (See New Hampshire Department of Revenue Administration, *Tobacco Tax Report*, various issues.) At the same time, the number of cigarettes taxed in Massachusetts declined by 153 million. Even if we subtracted out the entire increase in New Hampshire-taxed cigarettes as representing cross-border traffic, we would still observe a 24-percent decline in per capita consumption in Massachusetts.

large-scale surveys. I analyze data from the Behavioral Risk Factor Surveillance System (BRFSS) to compare trends in adult current smoking prevalence during 1989–1998 in Massachusetts, California, and the rest of the U.S. I compare the BRFSS-derived results in Massachusetts with those of the 1993–1994 Massachusetts Tobacco Survey and 1995–1998 Massachusetts Adult Tobacco Survey (MTS/MATS). I also analyze data on smoking prevalence in two target populations of special interest: pregnant mothers-to-be; and teenagers. Finally, I employ a widely accepted method for computing smoking-attributable health care costs to estimate the impact of the Campaign on public and private health care spending in the Commonwealth.

### **ADULT SMOKING PREVALENCE: ANALYSIS OF BEHAVIORAL RISK FACTOR SURVEILLANCE SYSTEM (BRFSS) DATA**

I analyzed data from the Massachusetts Behavioral Risk Factor Surveillance System in Massachusetts and other states from 1989 through 1998. The BRFSS is a population-based telephone survey of health practices that is conducted by individual state agencies (including the Massachusetts Department of Public Health) and supervised by the U.S. Centers for Disease Control (CDC). In all years, the Massachusetts Department of Public Health (MDPH) surveyed a "core sample" of participants according to sampling procedures outlined by the CDC. In more recent years, the MDPH also over-sampled certain counties or minority groups. In order to make consistent comparisons of surveys across states and over time, I relied upon the CDC-defined core samples.<sup>4</sup>

During the years prior to 1996, the main question in the BRFSS that elicited current smoking practices was "Do you smoke cigarettes now?" Starting in 1996, however, the CDC changed the wording of this question to "Do you now smoke cigarettes every day, some days, or not at all?"<sup>5</sup> Recent analyses have demonstrated that the change in the wording of the question has resulted in an increase in the estimated smoking prevalence by approximately 1 percentage point.<sup>6</sup>

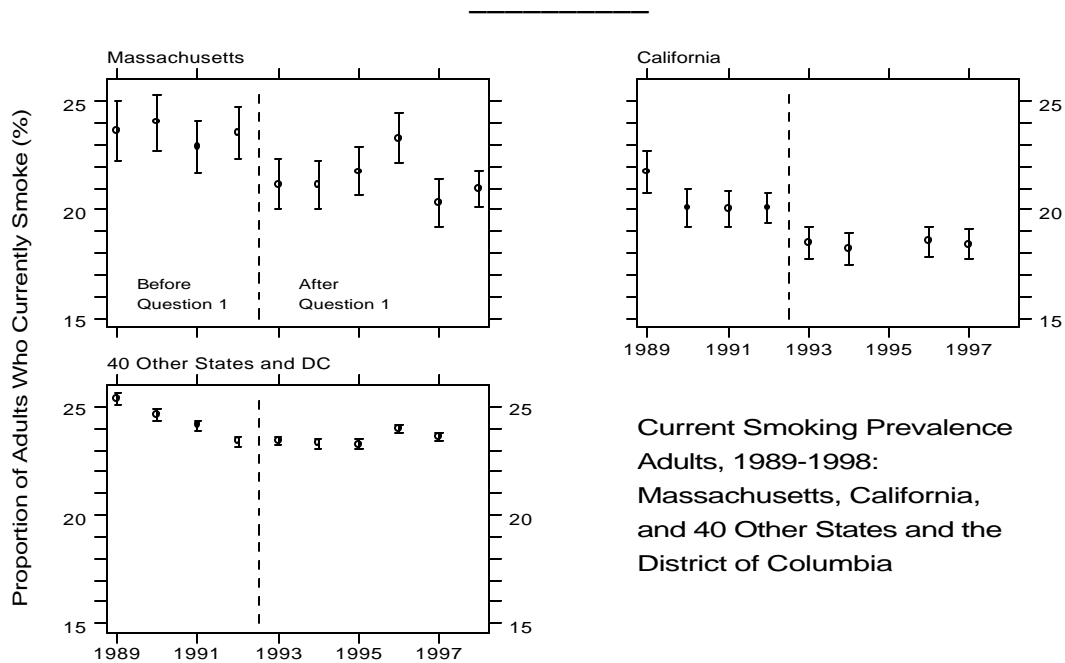
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<sup>4</sup> The only exception to this rule was the data set for the 1998 BRFSS (an electronic file named MA98SANS.SD2), in which a variable to distinguish the core sample from other respondents does not appear to have been included. All statistical analyses were performed with the *svy*mean procedure for complex surveys in Stata® Version 6.0.

<sup>5</sup> Massachusetts Department of Public Health. *Massachusetts Behavioral Risk Factor Surveillance System Questionnaire, 1996–1998*.

<sup>6</sup> See Centers for Disease Control. Cigarette smoking among adults – United States, 1992, and changes in the definition of current cigarette smoking. *Morbidity and Mortality Weekly Report*. May 20, 1994; 43:342–6. In the Cancer Epidemiology Supplement to the 1992 National Health Interview Survey, the estimated adult smoking prevalence was 25.6% under the old wording and 26.7% under the new wording.

Figure 2 shows trends in the percentage of respondents aged 18 year or more who answered affirmatively to the BRFSS question about current smoking. The open circles are the point estimates, while the vertical bars depict plus or minus 1 standard error. (The 95% confidence interval is approximately equal to 2 standard errors.) The upper left panel corresponds to Massachusetts, while the upper right corresponds to California, which instituted a tax-financed anti-smoking campaign in 1989. As a control group, I pooled the survey data on 40 other states and the District of Columbia that participated in the BRFSS in all years from 1989 through 1997. (The 11 excluded states were: Alaska, Arkansas, Colorado, Delaware, Kansas, Louisiana, Mississippi, New Jersey, Nevada, Vermont, and Wyoming.)

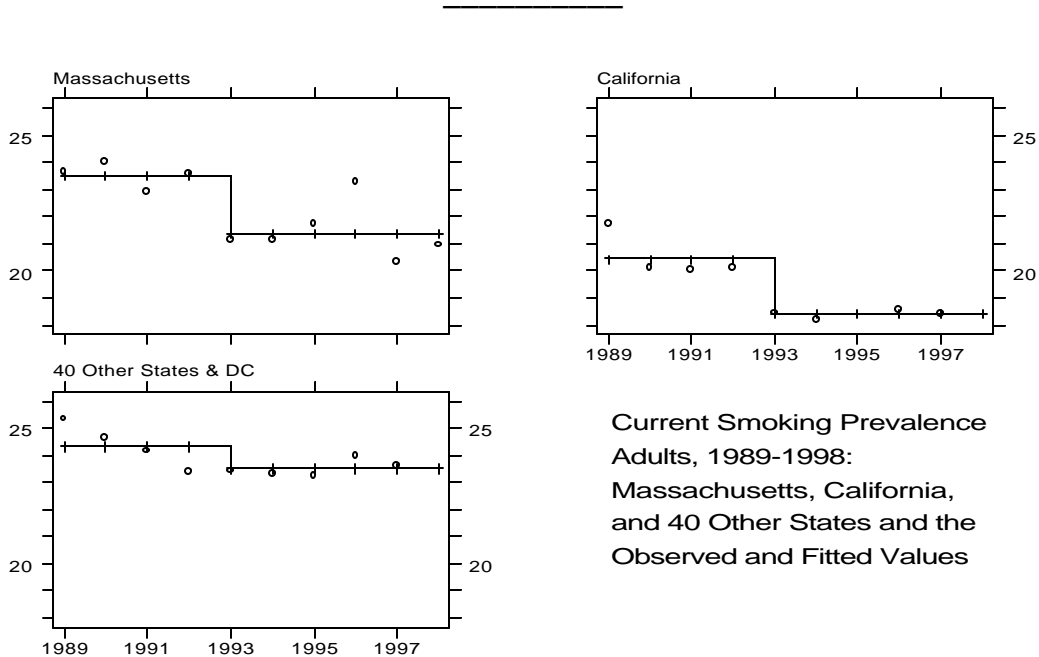


Source: Behavioral Risk Factor Surveillance Surveys  
 Notes: Vertical bars denote + 1 Standard Error

Figure 2. Prevalence of Current Cigarette Smoking among Adults. Massachusetts, California, and 40 Other States and the District of Columbia.

As Figure 2 shows, the prevalence estimates for the two individual states (Massachusetts and California) are not as precise as the combined estimate for the 40 remaining states and the District of Columbia. Nonetheless, with the exception of what appears to be an anomalous finding for Massachusetts in 1996, there is a

downward trend in Massachusetts and California compared to the rest of the nation.<sup>7</sup>



Source: Behavioral Risk Factor Surveillance Surveys

Figure 3. Observed and Fitted Values from the Weighted Analysis of Variance of the BRFSS Data in Figure 2.

To assess the observed differences in prevalence quantitatively, I performed a weighted analysis of variance (ANOVA) of smoking prevalence pre-1993 versus post-1992, where the regression weights equaled the inverses of the standard error of each estimate. The ANOVA model gave the following estimates for the change in prevalence after 1992: Massachusetts, a 2.13 percentage point drop (95% CI, 0.81–3.45%;  $P = 0.003$ ); California, a 2.05 percentage point drop (95% CI, 0.88–3.22%,  $P = 0.002$ ); and 40 other states, a 0.8 percentage point drop (95% CI, 0.20–1.42%,  $P = 0.012$ ). The fit of the ANOVA model to the data is shown in Figure 3 above.<sup>8</sup>

<sup>7</sup> No BRFSS survey data were collected in California in 1995.

<sup>8</sup> An F-test of the two-sided null hypothesis that the post-1992 decline in Massachusetts was no different than the post-1992 decline in the rest of the country was rejected at the  $P=0.07$  descriptive level of significance. By way of sensitivity analysis, I ran a similar ANOVA model on data from 1988 through 1998, which required exclusion of three more states (Oregon, Pennsylvania, and Virginia) from the control group. The estimated post-1992 decline in Massachusetts increased to 3.3

## **ADULT SMOKING PREVALENCE: ANALYSIS OF MASSACHUSETTS TOBACCO SURVEY (MTS) AND MASSACUSETTS ADULT TOBACCO SURVEY (MATS) SCREENING SAMPLES**

Under contract with the Massachusetts Department of Public Health, the Center for Survey Research (CSR) of the University of Massachusetts at Boston has conducted two surveys of adult smoking practices in the Commonwealth: the Massachusetts Tobacco Survey (MTS) from December 1993 through March 1994; and the Massachusetts Adult Tobacco Survey (MATS) that has been running continuously since March, 1995.<sup>9</sup> I analyzed the results of screening interviews with the adult informants who were contacted by telephone in each household. These screening interviews provide a much larger sample than the extended adult interviews that were also conducted.

While both the MTS and MATS were performed after the inception of the Massachusetts Tobacco Control Program, the trends can still be compared to those derived from the BRFSS. Figure 4 shows estimates of adult current smoking prevalence from the December 1993 – March 1994 MTS as well as the continuous household screening survey for 1995 through the end of 1998.

Given the relatively large sampling errors of the estimates in the two complex surveys, the results of the BRFSS are broadly consistent with those obtained in the MTS/MATS. During the four years prior to Question 1, approximately 23–24 percent of adults were current cigarette smokers. In 1997–1998, after the Campaign had been in place for over four years, approximately 20–21 percent of adults were current smokers. In view of the revision in the wording of the question eliciting current smoking practices in the BRFSS in 1996 – a revision adopted during all years of the MTS/MATS surveys – the decline in current smoking prevalence may have been larger.

Because the BRFSS and MTS/MATS were conducted by different methods, caution must be exercised when one combines the results of the two surveys. Nonetheless, I computed the precision-weighted average of the two survey results, where the MTS data were assigned to 1994. The resulting prevalence estimates were: 1994: 22.2% (1 S.E. =  $\pm 0.0043$ ); 1995: 21.6% ( $\pm 0.0058$ ); 1996: 21.9% ( $\pm 0.0059$ ); 1997:

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percentage points and the difference between Massachusetts and the rest of the country was significant at the  $P = 0.006$  descriptive level of significance.

<sup>9</sup> See: Center for Survey Research, University of Massachusetts at Boston. *Massachusetts Tobacco Survey: Screener Instrument Code Book*. July 11, 1994; *Massachusetts Adult Tobacco Survey: Survey Instrument Code Book*. Updated July, 1998; and L. Biener and A.M. Roman. 1997 *Adult Tobacco Survey: Technical Report & Tables*. Boston: Center for Survey Research, 1998.

20.4% ( $\pm 0.0053$ ); and 1998: 20.7% ( $\pm 0.0047$ ). The 1997-1998 prevalence was 1.4 percentage points below the 1994-1996 prevalence, and the difference was statistically significant (two-sided t-test,  $P = 0.01$ ).

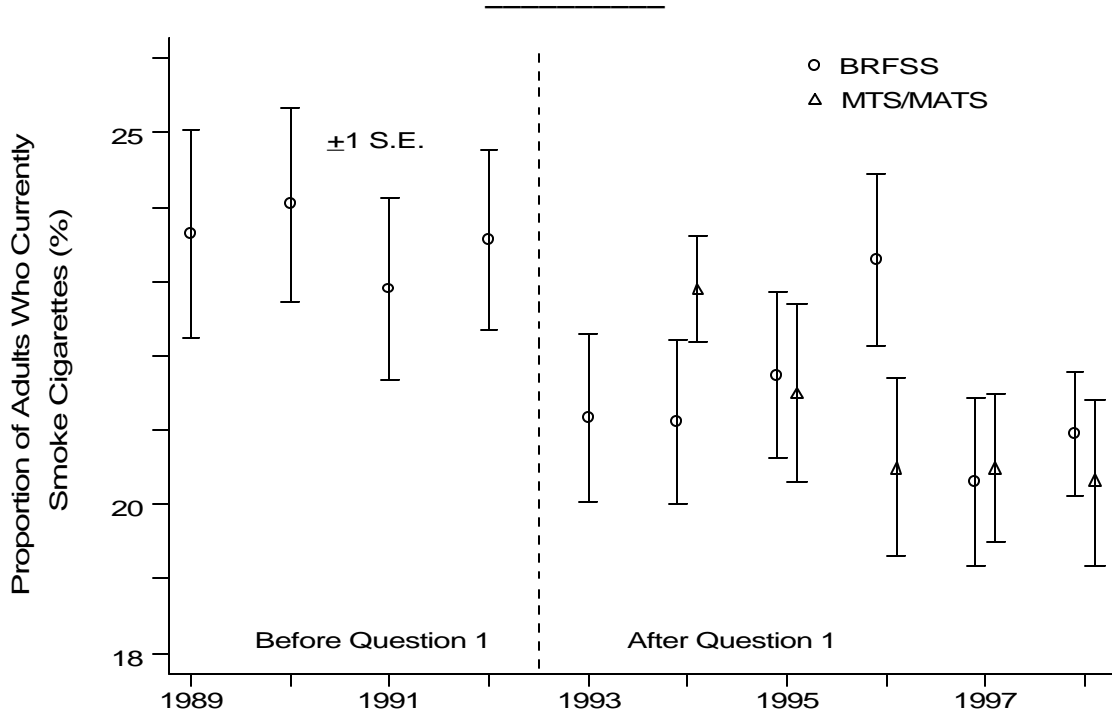


Figure 4. Comparison of estimates of adult smoking prevalence derived from; the Behavioral Risk Factor Surveillance System (BRFSS, open circles) and the screening interviews of the December 1993–March 1994 Massachusetts Tobacco Survey and 1995–1998 Massachusetts Adult Tobacco Survey (MTS/MATS, open triangles). The vertical bars indicated  $\pm 1$  standard error of the mean.

### SMOKING DURING PREGNANCY: BIRTH CERTIFICATE DATA

The National Center for Health Statistics recently reported on trends in the prevalence of maternal smoking during pregnancy.<sup>10</sup> The analysis was based upon maternal smoking practices recorded on birth certificates during 1990 through

<sup>10</sup> Matthews TJ. Smoking during pregnancy, 1990–1996. *National Vital Statistics Reports*. November 19, 1998; 47(10): 1–12. Internet: [http://www.cdc.gov/nchswww/data/nvs47\\_10.pdf](http://www.cdc.gov/nchswww/data/nvs47_10.pdf).

1996.<sup>11</sup> Figure 5 below shows a comparison of trends in maternal smoking during pregnancy in Massachusetts with the US as a whole.<sup>12</sup>

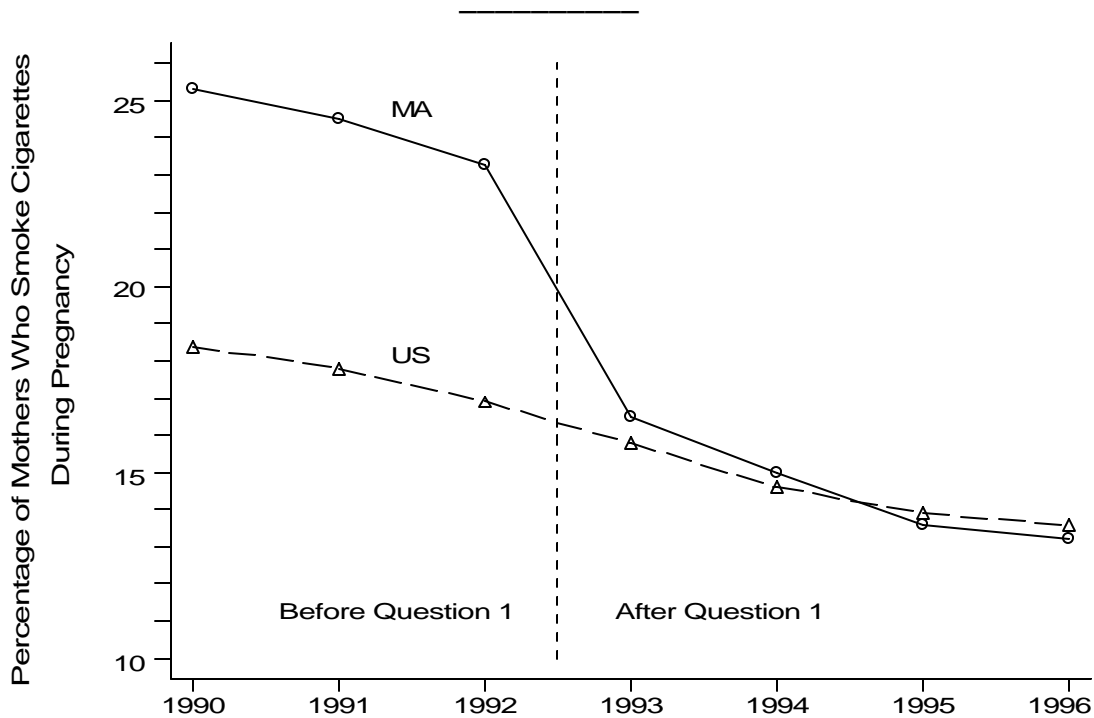


Figure 5. Trends in the Proportion of Mothers Who Smoked Cigarettes During Pregnancy in Massachusetts and All Reporting Areas in the U.S., 1990–1996, Based Upon Birth Certificates.

Source: Calculated from *National Vital Statistics Reports*. November 19, 1998, cited above.

<sup>11</sup> Valid data on smoking during pregnancy were not available on birth certificates from California, Indiana, New York state outside of New York City, and South Dakota. New York City began recording maternal smoking in 1994. Among states included in the analysis, 75 percent of live births in 1990 had data on maternal smoking, as compared to 79 percent in 1996.

<sup>12</sup> The inclusion of Massachusetts births in the US average is unlikely to have a significant effect on the overall conclusion. In 1994-1995, Massachusetts live births constituted only 2 percent of all live births in the states reporting maternal smoking. (Computed from: National Center for Health Statistics. Births, Marriages, Divorces, and Deaths for 1995 *Monthly Vital Statistics Report* July 24, 1996; 44(12):1–19. Internet: [http://www.cdc.gov/nchswww/data/mvs44\\_12.pdf](http://www.cdc.gov/nchswww/data/mvs44_12.pdf).)

Massachusetts experienced the largest overall decline during 1990–1996 in maternal smoking prevalence during pregnancy. The state's decline was 47.8% compared to 26.1% nationwide. The largest one-year drop in prevalence was from 23.3% in 1992 to 16.5% in 1993. By 1995, the state's rate had fallen below the national average, and by 1996 was down to 13.2%. In addition, the decline in the percentage of teenage mothers (aged 15–19) who smoked during pregnancy from 1990–1991 to 1995–1996 was 16% nationwide and 28% in Massachusetts.<sup>13</sup>

## **SMOKING AMONG TEENS: MASSACHUSETTS YOUTH TOBACCO SURVEY**

Several surveys of teenage smoking habits in the Commonwealth have been performed. The most recent Massachusetts Youth Risk Behavior Survey,<sup>14</sup> a survey of smoking and other risk-taking behaviors among students in randomly chosen public high schools in the state, reported a small decline in smoking in 1997 in comparison to 1995. In particular, the proportion of high school students who had smoked a cigarette within the past 30 days declined from 35.7% in 1995 to 34.4% in 1997. A more striking decline was seen among ninth-graders, where the proportion who ever tried cigarettes declined from 69% in 1995 to 62% in 1997.<sup>15</sup>

Here, I compare the results of the youth survey conducted as part of the 1993 Massachusetts Tobacco Survey with the 1999 Youth Tobacco Survey. Both surveys were conducted by the Center for Survey Research of the University of Massachusetts at Boston. The 1993 youth survey sampled 1,606 persons aged 12 years or more, of whom 1,095 were aged 14–17 years.<sup>16</sup> The 1999 Youth Tobacco Survey sampled 733 persons aged 14–18, of whom 729 were aged 14–17 years.<sup>17</sup>

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<sup>13</sup> Matthew TJ, *op. cit.*, Table 4.

<sup>14</sup> Massachusetts Department of Education. *Tobacco Use Among Massachusetts High School Students: 1997 Massachusetts Youth Risk Behavior Survey Results*, May 1998.

<sup>15</sup> With the exception of a decline in the proportion of 7th and 8th graders who ever tried cigarettes, the Health and Addictions Survey found little change in adolescent tobacco use in Massachusetts from 1993 to 1996. See Nancy J. Briton, Thomas W. Clark, Allison K. Baker, et al. *Adolescent Tobacco Use in Massachusetts: Trends Among Public School Students, 1984–1996*. Boston: Health and Addictions, Inc., May 1997.

<sup>16</sup> There were 558 respondents aged 14–15 and 537 respondents aged 16–17 in the 1993 Youth Survey. The results reported here were based upon an analysis of the youth "analytical file" (YTHANAL.SSD) provided by the Center for Survey Research.

<sup>17</sup> There were 375 respondents aged 14–15 and 354 respondents aged 16–17 in the 1999 Youth Tobacco Survey. The results reported here were based upon an analysis of the youth "analytical file" (FINAL733.SAV) provided by the Center for Survey Research.

Current research on tobacco use among young persons is based upon a continuum-of-addiction model of the onset of cigarette smoking. In such a model, children, adolescents and young adults progress through a sequence of stages: trying one cigarette; experimenting with cigarettes; regular smoking; and ultimately nicotine dependence. At each successive stage, symptoms of withdrawal become more pronounced and successful quitting becomes less likely.<sup>18</sup> Accordingly, researchers have employed a definition of a current youth smoker that differs from that used for adults. The most common definition is a "30-day current smoker," that is, an individual who has smoked at least one cigarette in the past 30 days.

Table 1. Comparison of 30-Day Current Smoking Prevalence Among Respondents Aged 14 – 17 Years in the 1993 and 1999 Youth Tobacco Surveys

Age Group	1993 Survey 30-day Prevalence (%) (± 1 Standard Error)	1999 Survey 30-Day Prevalence (%) (± 1 Standard Error)
14 – 15 years	15.3 ( 3.0)	14.0 ( 3.6)
16 – 17 years	33.7 ( 4.7)	25.2 ( 4.5)
14 – 17 years	24.6 ( 3.2)	19.6 ( 2.9)

Source: Based on data supplied by Center for Survey Research, University of Massachusetts at Boston.

Table 1 above shows the 1993–1999 comparison for 30-day smoking prevalence, broken down by age group. Because of the relatively small sample sizes and the complex nature of the stratified surveys, the standard errors surrounding the point estimates are too large to draw statistically precise conclusions. Still, the results are consistent with the conclusion that smoking has declined in the 6-year period since the institution of the MTCP.<sup>19</sup> Table 2 below shows the corresponding 1993–

<sup>18</sup> Jeffrey E. Harris and Sandra W. Chan, "The Continuum of Addiction: Cigarette Smoking in Relation to Price Among Americans Aged 15–29," *Health Economics Letters* 1998; 2:3–12. Reprinted in *Health Economics*, 1999; 8: 81–86.

<sup>19</sup> The 5-percentage-point decline in youth 30-day smoking prevalence had an estimated 95% confidence interval of –3.4 to 13.4 percentage points. A two-sided t-test of the difference between the 1993 and 1999 surveys was significant only at the P = 0.25 level. A test of the difference for 16- to-17-year-olds was significant only at the P = 0.19 level.

1999 comparison broken down by sex. Again, the samples are too small to draw statistically precise conclusions. Still, the results show consistent declines in both sexes.

Table 2. Comparison of 30-Day Current Smoking Prevalence Among Respondents Aged 14 – 17 Years in the 1993 and 1999 Youth Tobacco Surveys, By Sex

Sex	1993 Survey Daily Prevalence (%) (± 1 Standard Error)	1999 Survey Daily Prevalence (%) (± 1 Standard Error)
Male	25.1 ( 4.5)	20.1 ( 4.0)
Female	24.3 ( 4.3)	19.1 ( 4.3)
Both Sexes	24.6 ( 3.2)	19.6 ( 2.9)

Source: Based on data supplied by Center for Survey Research, University of Massachusetts at Boston.

**HEALTH CARE COST ANALYSIS: ESTIMATED DECLINE IN HEALTH CARE SPENDING IN THE COMMONWEALTH ATTRIBUTABLE TO THE CAMPAIGN**

With a 1998 adult population of approximately 4.7 million,<sup>20</sup> a 3-percentage-point decline in the prevalence of current smoking in Massachusetts translates into approximately 140,000 fewer adult smokers. Even a 2-percentage-point decline would mean 94,000 fewer current smokers. Here, I estimate the impact of the decline in smoking on total health care costs (including both public and private costs) in the Commonwealth.

While some health benefits of smoking cessation, including a reduction in the risk of lung cancer, accrue over several years, most other health benefits, such as a reduction in the risk of heart attack and stroke, accrue more rapidly.<sup>21</sup> In the

<sup>20</sup> For population estimates, see: <http://www.census.gov/population/estimates/state/5age9890.txt>.

<sup>21</sup> See: *The Health Benefits of Smoking Cessation: A Report of the Surgeon General*. Atlanta: U.S. Centers for Disease Control, Office on Smoking and Health, 1990. See also the studies reviewed in a meta-analysis by James M. Lightwood and Stanton A. Glantz. Short-term economic and health benefits of smoking cessation: Myocardial infarction and stroke. *Circulation* 1997; 96:1089–96.

accompanying mathematical appendix, I show how the standard, well-established formulas for measuring attributable risk can be used to estimate the proportion of total health-care spending that can result from a decline in smoking rates. I use the conservative assumption that a 2-percentage-point decline in adult smoking prevalence can be attributed to the Campaign. Moreover, I assume conservatively that there has been no change in smoking initiation, that is, the decline in adult smoking prevalence has resulted entirely from quitting. Under these assumptions, I estimate that the MTCP has reduced health care costs by an amount equal to 0.3% of the Commonwealth's current adult health-care spending.

Total public and private health care spending in the Commonwealth has been estimated to be about \$35.5 billion in 1999.<sup>22</sup> If approximately 80 percent of this expenditure is devoted to adults, then I estimate that the Campaign has reduced the Commonwealth's health care costs by  $\$35,500 \text{ million} \times 80\% \times 0.3\% = \$85 \text{ million}$  annually. In view of my conservative assumptions, the actual effect of the Campaign is likely to be greater.

## SUMMARY

1. Since the passage of Question 1 and the initiation of the Massachusetts Tobacco Control Campaign (MTCP) in 1993, tax-paid cigarette sales per adult have declined by 30 percent. There is little evidence that this decline is simply a statistical artifact caused by increased cross-border traffic to New Hampshire.
2. I analyzed the raw survey data on adult smoking practices from two sources: the Behavioral Risk Factor Surveillance System (1989–1998) sponsored by the U.S. Centers for Disease Control; and the Massachusetts Tobacco Survey (1993–1994) and Massachusetts Adult Tobacco Survey (1995–1998) conducted by the Center for Survey Research of the University of Massachusetts at Boston.
3. Since the initiation of the MTCP, the percentage of Massachusetts adults who describe themselves as current smokers has declined, while the prevalence of smoking in other states without tax-financed anti-smoking campaigns has remained nearly unchanged.

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<sup>22</sup> See: John F. Sheils, Randall A. Haight, and Theodore F. Kirby. *Massachusetts Comparative Projected Health Expenditure Model*. Fairfax VA: The Lewin Group, Inc., December 18, 1998. Internet: <http://www.massmed.org/physicians/resource/report1.pdf> (35.6\$ billion estimated in 1999); and Robert Brand, Alan Sager, David Ford, et al. *Universal Comprehensive Coverage: A Report to the Massachusetts Medical Society*. Philadelphia: Solutions for Progress, Inc. and the Access and Affordability Monitoring Project of the Boston University School of Public Health., December 1998. Internet: <http://www.massmed.org/physicians/resource/report1.pdf> (\$35.4 billion estimated in 1999).

4. During the four years prior to Question 1, approximately 23–24 percent of Massachusetts adults were current cigarette smokers. In 1997–1998, after the Campaign had been in place for over four years, approximately 20–21 percent of adults were current smokers. In view of a revision in the wording of the question eliciting current smoking practices, the actual decline in current smoking prevalence may have been larger.
5. I analyzed published data on the smoking rates of pregnant mothers-to-be during 1990 through 1996 in states that collected such information on birth certificates. Massachusetts experienced the largest overall decline during 1990–1996 in maternal smoking prevalence during pregnancy. The state's decline was 47.8% compared to 26.1% nationwide. The largest one-year drop in prevalence was from 23.3% of pregnant women in 1992 to 16.5% of pregnant women in 1993. By 1995, the smoking rate of pregnant women in the Commonwealth had fallen below the national average, and by 1996 was down to 13.2% of all mothers-to-be.
6. I analyzed the raw data from the 1993 and 1999 youth tobacco surveys conducted by the Center for Survey Research (CSR) of the University of Massachusetts at Boston. The proportion of 14-to-17-year-olds who had smoked a cigarette within the last 30 days declined from 24.6 to 19.6 percent. The decline in smoking prevalence was observed in both sexes and in both 14-to-15-year-olds and 16-to-17-year-olds.
7. Because of the small survey samples, I cannot conclude from the CSR youth tobacco surveys alone that the decline is statistically significant. However, the drop in teenage smoking appears to be consistent with other recent surveys, including the school-based 1997 Massachusetts Youth Risk Behavior Survey conducted by the Massachusetts Department of Education. The apparent decline in teenage smoking in Massachusetts runs counter to the observed rise in youth smoking that has been observed nationwide by the Monitoring The Future Surveys.<sup>23</sup>
8. I use a standard, well-established attributable risk method to estimate the reduction in total health care spending in the Commonwealth attributable to the Campaign. Under a conservative assumption that the Campaign reduced adult smoking prevalence by 2 percentage points and that there was no effect on initiation of smoking, I estimate that the Campaign has reduced total health care spending (public and private) by \$85 million annually. The actual reduction in health-care spending is likely to be higher.

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<sup>23</sup> "Monitoring the Future" Study. Cigarette Statistics Table 1: Long-Term Trends in Prevalence of Cigarettes for Eighth, Tenth, and Twelfth Graders. Ann Arbor: University of Michigan, 1997. Internet: <http://www.isr.umich.edu/src/mtf/mtfcig1.html>.

## APPENDIX: ATTRIBUTABLE RISK MATHEMATICS

This appendix shows how standard, well-established formulas for determining attributable risk<sup>24</sup> can be used to estimate the proportion of health-care spending that can result from a decline in smoking rates.

Let  $p_C$  and  $p_F$  denote the prevalence of current and former smoking, respectively, in a population at a particular point in time. (Hence, the prevalence among individuals who never smoked is equal to  $1 - p_C - p_F$ .) Let  $r_C$  and  $r_F$  denote the relative health care spending of current and former smokers, respectively, in comparison to persons who never smoked. (That is, a current smoker spends  $r_C$  dollars on health care for every dollar spent by a person who never smoked, while a former smoker spends  $r_F$  dollars. The relative risk for a person who never smoked is, by definition, equal to 1.) In addition, let  $X$  denote the per-capita health-care spending among individuals who never smoked, and let  $N$  denote the number of individuals in the entire population. Then the total health care expenditures ( $E$ ) of the entire population is given by:

$$E = NX(r_C p_C + r_F p_F + 1 - p_C - p_F) \quad (1).$$

Now consider the effect of a decrease in the prevalence of current smoking from  $p_C$  to  $p_C'$  and an increase in the prevalence of former smoking from  $p_F$  to  $p_F'$ . The health care expenditure after the change in smoking prevalence is:

$$E' = NX(r_C p_C' + r_F p_F' + 1 - p_C' - p_F') \quad (2).$$

Let  $\Delta p_C = p_C - p_C'$  denote the decline in current smoking prevalence. If this decline results entirely from current smokers' quitting, then the increase in former smoking prevalence is likewise equal to  $\Delta p_C$ . Therefore, the reduction in total health care costs resulting from the decline in current smoking is equal to:

$$\Delta E = E - E' = NX(r_C - r_F) \Delta p_C \quad (3).$$

The proportional reduction in total health care spending resulting from the decline in current smoking is therefore:

$$h = \frac{\Delta E}{E'} = \frac{(r_C - r_F) \Delta p_C}{1 + p_C'(r_C - 1) + p_F'(r_F - 1)} \quad (4).$$

<sup>24</sup> Jeffrey E. Harris, "Trends in Smoking-Attributable Mortality," Chapter 3 in: *Reducing the Health Consequences of Smoking, 25 Years of Progress: A Report of the Surgeon General*. Washington DC: US Department of Health and Human Services, 1989: 117-169.

We can determine  $p_C'$  and  $p_F'$  from survey data on contemporary smoking prevalence, and we can measure  $\Delta p_C$  from survey data on past trends in smoking. Estimates of the relative risks  $r_C$  and  $r_F$  can be derived from epidemiological evidence or from studies of the health care spending of smokers in comparison to non-smokers. Finally, once we have an estimate of  $h$ , we can use data on current health care spending  $E'$  to compute  $\Delta E = hE'$ .

In the present analysis, I assumed conservatively that the Massachusetts Tobacco Control Campaign was responsible for 2 percentage point decline in adult current smoking prevalence, that is,  $\Delta p_C = 0.02$ . I took the contemporary values of  $p_C' = 0.203$  and  $p_F' = 0.310$  from the 1998 Massachusetts Adult Tobacco Survey (MATS). I derived the relative risks  $r_C = 1.23$  and  $r_F = 1.07$  from a meta-analysis of studies of health care spending of smokers in comparison to non-smokers.<sup>25</sup> Based upon these parameters, I estimated a value of  $h$  from equation (4) to equal 
$$\frac{(1.23 - 1.07) \times 0.02}{1 + 0.203 \times (1.23 - 1) + 0.310 \times (1.07 - 1)} = 0.003$$
. That is, the MTCP-related decline in smoking has been responsible for 0.3 percent reduction in total health care costs.

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<sup>25</sup> See Jeffrey E. Harris. *Proportion of Health-Care Spending Attributable to Tobacco Manufacturers' Anti-Competitive Conduct: State of Maryland Medicaid Program, 1970-1997*. Expert's Report in: *State of Maryland v. Philip Morris, Inc. et al.* July 28, 1998