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Estimating the return on investment of the Bureau of Tobacco Free Florida tobacco control programme from 1999 to 2015

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ABSTRACT

Objective To assess the return on investment (ROI) of the Florida tobacco control programme, the Bureau of Tobacco Free Florida (BTFF), in terms of healthcare expenditure savings and mortality cost saved as a result of reduced mortality due to the programme from 1999 to 2015.

Methods We use a synthetic control method to estimate the impact of the BTFF on smoking-attributable mortality, years of life lost (YLL), healthcare expenditures, and the economic value of premature mortality due to smoking in Florida from 1999 through 2015. We calculated an ROI for healthcare expenditures and for the value of life years saved.

Results From 1999 to 2015, adult smoking prevalence in Florida averaged 0.98 percentage points lower than prevalence in the synthetic control states (19.6% vs 20.6%). The ROI over the period from 1999 to 2015 was 9.61 for healthcare expenditures and 112.44 for premature mortality. These ROIs suggest that for every US$1 of expenditure by BTFF, smoking-attributable healthcare expenditures decreased by almost US$11 and reductions in the economic costs associated with YLL due to smoking-attributable mortality totaled approximately US$113.

Conclusions Our results suggest the BTFF resulted in fewer YLL, substantial healthcare cost savings and substantial savings in terms of mortality costs. The positive ROIs for healthcare expenditures and premature mortality suggest that the BTFF is a good investment of public funds.

Strengths and limitations of this study

- ► Our study uses a synthetic control group method to establish the effectiveness of the Bureau of Tobacco Free Florida (BTFF).
- ► We estimate the return on investment of BTFF expenditures in terms of smoking-attributable healthcare expenditure savings and reductions in premature smoking-attributable mortality.
- ► A limitation of our study is that the synthetic control group is not a perfect fit for Florida in the period prior to the start of the BTFF and that the synthetic control group had some tobacco control funding in the period after the start of the BTFF.
- ► Another limitation is that we do not consider all possible costs of smoking.

BACKGROUND

The Bureau of Tobacco Free Florida (BTFF) is one of the largest statewide tobacco control programmes in the USA. The programme's goal is to protect people from the health hazards of using tobacco by discouraging tobacco use. The programme began in 1998 as the result of a lawsuit settlement with tobacco companies to cover costs of smoking to the state's Medicaid programme. BTFF funded a youth-focused media campaign, a statewide youth empowerment programme, Students Working Against Tobacco, local community partnerships, and promoted curriculum-based tobacco use prevention education. The youth-focused media campaign has been shown to be associated with declines in youth smoking.[1–3] Annual programme funding ranged from US$17 to US$49 million between 1999 and 2003 and dropped to less than US$1 million from 2004 to 2006. Several studies showed that the funding reductions from 2004 to 2006 reduced the effect of the programme.[4 5] Funding was fully restored in 2007 as the result of a state constitutional ballot initiative, and BTFF began to administer the programme consistent with the recommendations from the Centers for Disease Control and Prevention (CDC) Best Practices for Comprehensive Tobacco Control Programs. From 2008 to 2015, annual allocations to a comprehensive statewide tobacco programme ranged from US$52 to US$67 million, and Florida was ranked among the top 15 states in reaching the CDC's recommended funding levels.[6] Since 2007, BTFF consists of the five programme components of a comprehensive tobacco control programme: state and community; mass-reach health communications; cessation; surveillance and evaluation; and infrastructure, administration and management. Studies have shown that the BTFF media campaign has increased use of state-sponsored cessation services, increased population-level quit attempts statewide and reduced relapse among quitters in Florida.[7–9]

Several studies have also examined the impact of tobacco control programmes in terms of healthcare expenditure savings resulting from reductions in prevalence relative to programme expenditures. A study by Dilley *et al*[10] compared smoking prevalence in Washington with the national average to determine the effectiveness of the tobacco control programme. They found that during a 10-year period of funding for the state tobacco control programme in Washington, the state saved US$5.73 in costs associated with fewer hospitalisations for every US$1 spent by the programme. A study by Richard *et al*[11] examined the return on investment (ROI) of a Medicaid tobacco cessation programme in Massachusetts. They found an ROI of 2.12 in terms of medical care savings.[11]

Lightwood and Glantz[12 13] estimated the impact of the California and Arizona tobacco control programmes in terms of healthcare expenditure savings from reductions in smoking prevalence and reductions in consumption. In both analyses, they used a control group of 38 states that did not have substantial tobacco control programmes or tobacco taxes of 50 cents per pack or more. They found that in California, the tobacco control programme resulted in healthcare expenditure savings of US$50 for every US$1 of programme spending. In Arizona, they found a ratio of healthcare expenditure savings to programme spending of 10 to 1.

Abadie *et al*[14] used a synthetic control method to assess Proposition 99 in California. They found that after Proposition 99 passed, tobacco consumption declined in California relative to a synthetic comparison group for California. In Abadie, the authors argue for the importance of using a synthetic comparison group (ie, in using data-driven methods to select a comparison group vs using, eg, the rest of the USA as the comparison group) in such analyses.

In this paper, we assess the ROI of the BTFF in terms of (1) healthcare expenditure savings—a measure of direct costs saved due to programme expenditures from 1999 to 2015, and (2) mortality costs saved as a result of reduced mortality due to the programme—a measure of the indirect costs saved due to programme expenditures from 1999 to 2015.

METHODS

Data

To conduct our synthetic control analysis, we used data from CDC's Behavioral Risk Factor Surveillance System for 1991 to 2015.[15] We used data on state demographics (age and gender distributions) obtained from the US Census.[16–19] We obtained state-specific income and poverty levels from the Annual Social and Economic Supplement of the Current Population Survey.[20 21]

We used data from CDC's recommended funding levels from 2014[6] to identify state-specific funding recommendation thresholds. We updated this data to year-specific funding recommendations for each state for 1999 through 2015, adjusted using the consumer price index (CPI). Data on state tobacco control programme funding was collected by RTI International. Tobacco control programme funding data reflect funding from federal (eg, CDC's National Tobacco Control Program), state (eg, revenues from cigarette taxes, revenues from the Master Settlement Agreement), and non-government (eg, Robert Wood Johnson Foundation, American Legacy Foundation) sources.

We obtained annual estimates of both total and smoking-attributable mortality as well as average remaining life expectancy in Florida for the years 1999 through 2015 from the 2017 Global Burden of Disease (GBD) study.[22] These data capture premature mortality and disability from more than 300 diseases and injuries by geography, year, age and gender. We obtained data on nominal annual healthcare expenditure data by state of residence and type of medical care for 1991 through 2014 from The Centers for Medicare and Medicaid Services (CMS).[23]

Analysis

Synthetic control estimation

To estimate the impact of BTFF funding on smoking prevalence, we used a synthetic control method[14] to compare adult smoking prevalence in Florida with a synthetic control. The synthetic control method essentially creates a comparison group for Florida that best matches the adult smoking prevalence trend in Florida in the period prior to implementation of the BTFF programme (the pretreatment period, which in our analysis is the years 1991–1998). The synthetic control group represents what the trend in Florida adult smoking prevalence would have been in the posttreatment period (1999–2015) had there been no BTFF in Florida. To construct a synthetic comparison for Florida, the synthetic control method combined a set of states to form the synthetic control based on predictors of adult smoking prevalence. We used as predictors the percentage of the population aged 18+, the percentage of the population that is male, the percentage of the population that reported making a quit attempt in the past year, the median income of the state, the poverty rate, the percentage of respondents who reported drinking in the past week, and the percentage of adults who reported exercising any in the past week. These variables were averaged over the 1991–1998 period and augmented by adding 3 years of lagged smoking prevalence: 1991, 1995 and 1998. To identify states for the control group that did not have significant levels of tobacco control programme funding we compared the CDC-recommended funding levels for each state with the state's level of tobacco control programme funding. We used the Stata package synth[24] to conduct the synthetic control analysis for the selected states. The model with the lowest

Table 1 Comparison of Florida with synthetic control across predictor variables

Variable	Florida	Synthetic control
% Current smoker (1998)	22.0	22.9
% Current smoker (1995)	23.2	23.1
% Current smoker (1991)	25.0	24.1
% Population male	48.6	48.7
% Population over 18	77.5	74.4
% Made a quit attempt	49.6	49.1
Median income	48605	56844
Poverty rate (%)	15.2	13.8
Drink any in the past week (%)	54.1	48.6
Exercised any in the past week (%)	71.7	69.4

mean-squared predicted error (MSPE) included smoking lags, % male, % population 18+, % quit attempts, median income, poverty rate, % drink and % exercise (see online supplemental appendix 1 for more details).

The results indicated that the smoking trends in Florida, in the period before programme funding began, are best reproduced by a combination of Alabama (21%), Michigan (15.6%), New Jersey (31.8%), Tennessee (11.2%) and Texas (20.5%). See online supplemental appendix 1 for a list of potential control states included in the model and the relative weights of each state used to construct the synthetic control for Florida. States with a zero weight are not part of the synthetic control.

Table 1 contains the comparison of Florida with the synthetic control for the selected predictor variables. The pretreatment characteristics in Florida are closely mirrored by the synthetic control. Online supplemental appendix 1 also provides a comparison of Florida and the synthetic control states on several tobacco control policy measures (cigarette excise taxes and clean indoor air laws).

We conducted placebo tests for our selected synthetic control model following the procedure outlined in Abadie *et al*.[14] For the placebo tests, we replace Florida with each potential donor to the synthetic control group, placing Florida in the donor pool as a potential control state, and re-estimate the synthetic control model. We then calculate the ratio of the MSPE in the postprogramme period to the MSPE in the preprogramme period. This results in 13 tests in our case. We compare the ratio of pre-MSPE to post-MSPEs in Florida to those for each potential donor to the synthetic control (see online supplemental appendix 1).

We also conducted a sensitivity analysis. For this, we conducted the synthetic control estimation and calculated the ROI for each of six model specifications which had the next six lowest MSPEs compared with our selected model. This creates a new synthetic control group and then compares Florida to the new synthetic control created. We report the mean and median ROIs across these six models (see online supplemental appendix 1). This gives us six new ROIs and is a measure of the sensitivity of our results to the specific model and synthetic control group we create.

Smoking-attributable costs

Smoking-attributable healthcare expenditures (direct costs)

We estimated total healthcare expenditures in Florida in 2015 based on the average annual growth in total healthcare expenditures in Florida over the last 10 years of available CMS data (2004–2014). We adjusted nominal annual total healthcare expenditures in Florida for the years 1999 through 2015 for inflation using the national CPI for medical care produced by the Bureau of Labor Statistics.[25] All healthcare expenditures presented in this paper are expressed in real, inflation-adjusted, 2015 dollars. We calculated annual smoking-attributable healthcare expenditures in Florida by multiplying inflation-adjusted total annual healthcare expenditures in Florida by annual estimates of the smoking-attributable fraction (SAF) for healthcare expenditures in Florida. We obtained estimates of the SAF of healthcare expenditures in Florida in 1993 from Miller *et al*.[26] They calculated SAFs based on a two-part model of annual individual expenditures estimated using the 1987 National Medical Expenditure Survey.

Because new estimates of SAF specific to Florida are not readily available and are difficult to obtain given the data requirements for producing such estimates, we adjusted the 1993 SAF for Florida to account for changes in adult smoking prevalence in Florida over the years from 1994 through 2015. The SAF estimates reported by Miller *et al*[26] exclude healthcare expenditures for dental care. We follow that approach and exclude healthcare expenditures for dental services from our analysis.

Smoking-attributable mortality (indirect costs)

The SAF for smoking-attributable mortality represents the fraction of total deaths in Florida that were due to smoking. Using GBD data on total and smoking-attributable mortality in Florida, we derived the SAF of mortality associated with smoking in Florida for each gender, 5-year age group, and each of the 33 specific causes included in our analytic data. We calculated smoking-attributable years of life lost (YLL) using GBD data on smoking-attributable deaths (SAD) in Florida as well as GBD data on average remaining life expectancy by gender and 5-year age group. To calculate YLL, we multiplied the annual number of SAD for each gender and 5-year age group by the average remaining life expectancy for that gender and 5-year age group.

Estimating the economic value of premature mortality due to smoking in Florida

We calculated the economic value of premature mortality due to smoking in Florida using a value of a statistical life year approach. We used a life year (LY) value of US\$200 000.[27] We updated this for inflation using the CPI to US\$235 135 in real, inflation-adjusted, 2015 dollars. Consistent with the US Food and Drug Administration practice, we used a social discount rate of 3% in calculating LY values.[28]

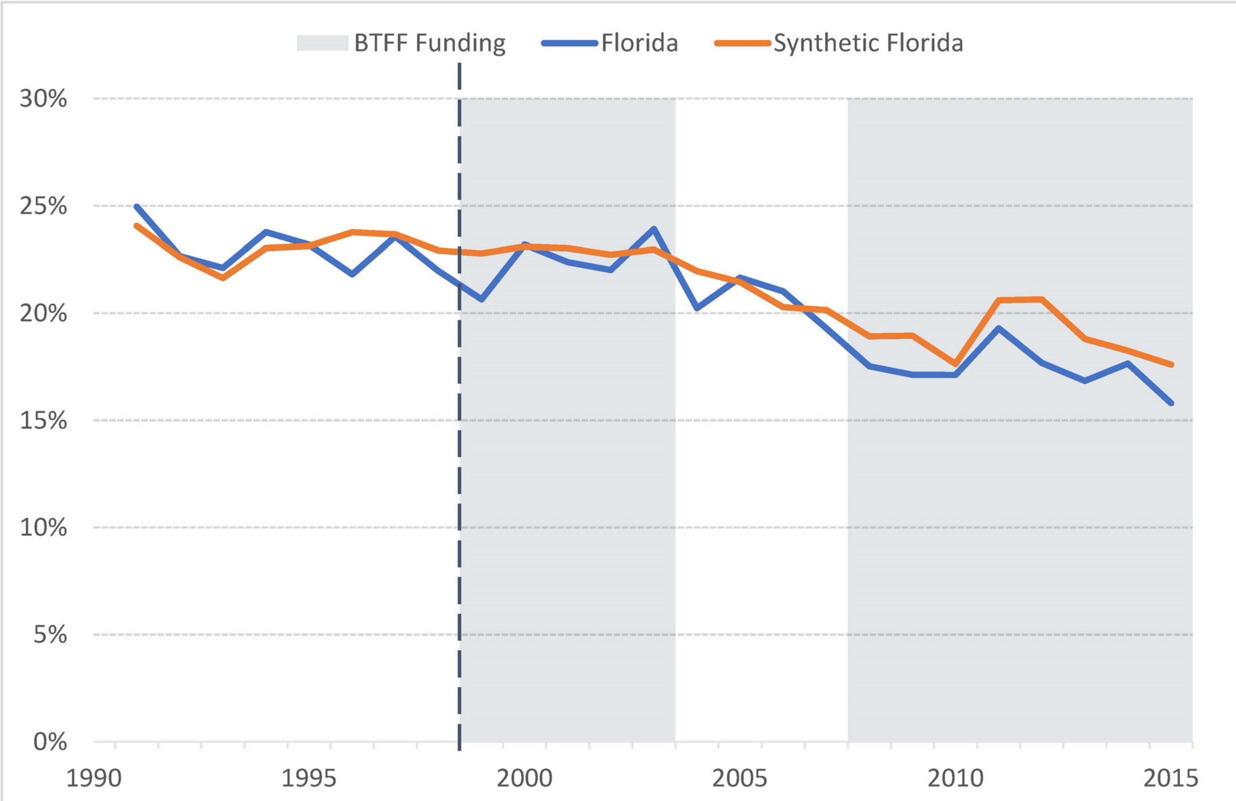

Figure 1 Results of the synthetic control analysis. BTFF, Bureau of Tobacco Free Florida.

Estimating the impact of the BTFF on SAD and costs

To estimate the impact of the BTFF on SAD, YLL, healthcare expenditures, and the economic value of premature mortality due to smoking in Florida from 1999 through 2015, we took the difference in each of those smoking-attributable outcomes in Florida between the synthetic control and the estimates for Florida based on estimates of adult smoking prevalence.

ROI

We calculated the ROI for healthcare expenditure savings and for the value of LYs saved. The ROI was calculated as the net savings divided by programme costs, where net savings is the difference between the value of healthcare expenditures or LYs saved as a result of the programme and the programme costs. For healthcare expenditures and mortality costs (valuation of LY saved), we calculated the cumulative total by summing annual values, as well as tobacco control programme expenditures, from 1999 to 2015.

Patient and public involvement

No patients were involved in this study.

RESULTS

Synthetic control

Figure 1 shows the annual adult smoking prevalence in Florida and the synthetic control for the analysis period (1991 through 2015). The years in which the BTFF was funded is indicated by the grey shading. The average smoking rate in Florida was 23.0% in the pretreatment period (1991–1998), compared with 23.1% in the synthetic control during the same time period. In 2004 before the defunding of the BTFF, the smoking rate was 20.2% in Florida compared with 22.0% in the synthetic control. During the years that the BTFF was refunded (2008–2015), the average smoking rates in Florida and the synthetic control were 17.% and 18.9%, respectively. The smoking prevalence in the synthetic control is consistently higher than in Florida for all years following refunding. The full prevalence estimates can be found in online supplemental appendix 1. Our estimate of the effect of the BTFF on adult smoking prevalence is the difference between prevalence in Florida compared with the synthetic control in the post-treatment period (1999–2015). We use this estimated reduction in smoking prevalence to quantify the cost savings in Florida resulting from the tobacco control programme.

Following the model selection, we performed placebo tests as described above in methods (See online supplemental appendix 1). We found that of the 13 placebo tests conducted, the MSPE ratio for FL was larger than 11 of the MSPE ratios for synthetic control states, that is, Florida in a sense passed 11 of 13 placebo tests. We interpret these results to suggest that the difference observed in smoking prevalence between Florida and synthetic Florida was likely a result of the Florida BTFF. We also conducted a sensitivity analysis in which we conducted the synthetic

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Table 2 Smoking-attributable healthcare expenditures in Florida, 1999–2015

Year	Total healthcare expenditures (Real US$ 2015)*	Smoking-attributable fraction of healthcare expenditures (SAF)		Smoking-attributable healthcare expenditures (SAE) (Real US$ 2015)		
		Actual (%)	Synthetic control (%)	Actual (US$)	Synthetic control (US$)	Difference (US$)
1999	111 384 956 770	6.54	7.24	7 288 507 407	8 066 891 693	778 384 286
2000	117 032 600 971	7.37	7.34	8 624 614 265	8 587 439 203	(37 175 061)
2001	121 373 108 153	7.12	7.31	8 636 053 625	8 867 376 490	231 322 865
2002	125 192 260 103	6.99	7.21	8 748 729 706	9 027 098 378	278 368 672
2003	130 697 915 944	7.59	7.31	9 922 278 254	9 548 635 977	(373 642 277)
2004	136 212 563 609	6.42	6.99	8 740 039 081	9 518 854 445	778 815 364
2005	140 287 342 010	6.89	6.83	9 669 923 963	9 580 800 240	(89 123 723)
2006	144 855 575 860	6.67	6.45	9 662 719 001	9 340 628 368	(322 090 633)
2007	147 036 455 099	6.13	6.38	9 014 199 618	9 387 845 198	373 645 580
2008	149 108 792 106	5.56	6.00	8 288 694 620	8 951 790 190	663 095 570
2009	152 016 527 039	5.43	6.04	8 257 180 063	9 174 644 514	917 464 451
2010	152 070 252 135	5.43	5.59	8 260 098 284	8 501 621 625	241 523 342
2011	151 672 788 801	6.13	6.54	9 298 434 146	9 924 753 545	626 319 398
2012	152 493 109 125	5.62	6.54	8 573 700 806	9 978 431 446	1 404 730 641
2013	151 612 441 195	5.34	5.97	8 090 753 332	9 053 938 253	963 184 921
2014	158 129 242 447	5.59	5.78	8 840 354 825	9 141 730 557	301 375 733
2015	162 632 502 473	5.02	5.59	8 162 238 301	9 092 113 550	929 875 249
Annual avg.	141 400 496 108	6.23	6.54	8 710 501 135	9 161 446 687	450 945 552
Total	2 403 808 433 840			148 078 519 296	155 744 593 672	7 666 074 376

*Excluding dental care expenditures.

control analysis and calculated the ROI for each of the six models which had the next lowest MSPE's for the comparison of smoking prevalence in Florida to the synthetic control group in the preprogramme period (see online supplemental appendix 1). These results show that the average ROI across these different models (each would compare Florida to a different selected synthetic Florida) was 5.7 (compared with our estimate from the best model of 9.6) for healthcare utilisation and 52.9 (compared with our estimate of 112.4) for mortality.

Smoking-attributable costs

Healthcare (direct) costs

Table 2 presents annual estimates of both total and smoking-attributable healthcare expenditures in Florida for the years 1999 through 2015. Smoking-attributable healthcare expenditures in Florida are presented for adult smoking prevalence in Florida and the synthetic control over those years. In 2015, smoking-attributable healthcare expenditures in Florida were estimated to be approximately US$8.16 billion. Had adult smoking prevalence remained at the higher level estimated by the synthetic control, smoking-attributable healthcare expenditures in Florida in 2015 would have been an estimated US$9.09 billion. The reduction in adult smoking in Florida in 2015, when compared with the synthetic control, represents a savings of nearly US$929.9 million in direct healthcare expenditures in Florida in 2015. The average annual savings in smoking-attributable healthcare expenditures in Florida from 1999 through 2015 was nearly US$451 million. Cumulatively, the reductions in adult smoking prevalence in Florida from 1999 through 2015, compared with the synthetic control, amount to nearly US$7.67 billion in smoking-attributable healthcare expenditures.

Mortality (indirect) costs

Table 3 presents SAD and the YLL due to SAD. Over the years 1999–2015, there were an estimated 544 121 SAD in Florida. SAD in Florida from 1999 to 2015 resulted in an estimated 8 384 783 YLL due to premature mortality. Had adult smoking prevalence in Florida been equal to the levels from the synthetic control over the years 1999–2015, there would have been an estimated 573 127 SAD in Florida, leading to an estimated 8 836 184 YLL. The difference in adult smoking prevalence in Florida over the years 1999–2015, compared with the synthetic control prevalence, resulted in an estimated 29 006 SAD averted in Florida during the years 1999–2015 resulting in an estimated 451 402 YLL averted as a result of BTFF funding.

Table 3 Smoking-attributable deaths (SAD) and years of life lost (YLL) in Florida, 1999–2015

Outcome	Actual	Synthetic control	Difference (synthetic control—Florida)
SAD	544 121	573 127	29 006
Smoking-attributable YLL	8 384 783	8 836 184	451 402
Economic value of smoking-attributable years of life lost	US$1.52 trillion	US$1.61 trillion	US$81.93 billion

Table 3 presents estimates of the economic value of the YLL due to SAD. Over the years 1999–2015, the economic value of the YLL due to SAD in Florida was approximately $1.52 trillion. Had adult smoking prevalence remained at the higher level that we estimated for the synthetic control, the economic value of the YLL due to SAD in Florida over the years 1999–2015 would have been an estimated $1.61 trillion. The reductions in adult smoking prevalence in Florida, compared with the synthetic control, resulted in an estimated savings in the economic value of YLL due to SAD of approximately $81.93 billion over the years 1999–2015.

Return on investment

The ROI results are summarised in table 4. From 1999 through 2015, smoking-attributable healthcare expenditures in Florida were nearly US$7.7 billion lower than they would have been had adult smoking prevalence in Florida remained at the higher level of the synthetic control. Over that same period, Florida spent a total of US$722.3 million on its tobacco control programme (in real, inflation-adjusted, 2015 dollars). The ROI for smoking-attributable healthcare expenditures in Florida from 1999 through 2015 was nearly 10:1. In terms of the economic value of the YLL due to SAD, the ROI in Florida from 1999 to 2015 was approximately 112:1. These ROIs suggest that for every US$1 of expenditure by BTFF from 1999 to 2015, over the same period smoking-attributable healthcare expenditures decreased by almost US$11 and the economic cost of LY lost due to SAD decreased by approximately US$113.

DISCUSSION

This study contributes to the literature providing evidence on the effectiveness and efficiency for comprehensive state tobacco control programmes. While there is evidence that state tobacco control programmes reduce tobacco use and programme components are cost effective, few studies have reported on their ROI. State tobacco control programmes likely vary in the funding levels, implementation and effectiveness given their different sociodemographic and economic contexts. Thus, state-specific assessments are necessary to determine effectiveness, build support for programmes and provide useful information to decision-makers in a state. This study has relevance for building the case for comprehensive state tobacco control programmes in general as well as for decision-makers in the state of Florida.

Our results suggest that the BTFF had a significant role in reducing smoking prevalence. The difference in reductions of smoking prevalence between Florida and the synthetic control was greater following the refunding of the programme in 2007. These reductions in smoking prevalence translated into substantial savings of healthcare expenditures, reductions in smoking-attributable mortality and YLL, and the economic costs associated with reductions in premature smoking-attributable mortality. We also found positive ROIs for the FL BTFF programme in terms of both healthcare expenditures and mortality. Study results suggest that the BTFF programme generated savings or cost reductions in excess of programme expenditures.

Our results are consistent with other studies finding a positive ROI for tobacco control programmes suggesting they are worthwhile investments of public money and generate substantially more savings than are spent to fund the programme. The ROIs we estimate for the BTFF programme also compare favourably to other public health interventions. A review of ROI studies of public health interventions found a median ROI across all interventions of 14.1.[29] Our estimated ROI in terms of healthcare expenditures is close to this median value across all interventions while our estimated ROI for mortality (economic valuation of YLL) is considerably higher.

As with any study of this type, our study has several limitations. First, although we created a synthetic control for Florida, our synthetic control states had some levels of tobacco control expenditures. An ideal control would have had no funding. However, this suggests that our estimate of the ROI is conservative and if we had only states with no funding, we would have found a larger ROI for Florida. Second, our method is based on a comparison of adult smoking prevalence in Florida to a synthetic control assuming the control represents what adult smoking

Table 4 Healthcare and mortality return on investment (ROI)

Category	Savings	Programme costs	Net savings	ROI
Healthcare	US$7 666 074 376	US$722 260 109	US6$ 943 814 268	9.61
Mortality	US$81 930 432 902	US$722 260 109	US$81 208 172 793	112.44

prevalence would have been in Florida with no tobacco control programme. Since we do not control explicitly for cigarette excise taxes, clean indoor air laws, or other factors that might influence smoking prevalence, if there were differences in these policies between Florida and the synthetic control in the post-treatment period, we might have overestimated or underestimated the effectiveness of the Florida programme. In online supplemental appendix 1, we compare Florida to the synthetic control group on these tobacco control policies. The synthetic control had more tax increases and a higher tax level in the post period than Florida. Florida had a higher percentage of its population covered by workplace and restaurant clean indoor air laws but less of the population covered by smoke-free bars compared with the synthetic control. These results show that synthetic control states implemented tobacco control policies in the period after the start of the Florida BTFF and thus supports our contention that our estimated ROI for the FL BTFF is likely an underestimate. Third, the synthetic control was not a perfect fit for the trend in smoking prevalence for Florida in the pretreatment period. Any difference in trend in the pretreatment period could bias estimates of differences in smoking prevalence between Florida and the synthetic control and thus of the ROI. A simple regression model of smoking prevalence in Florida and synthetic control in the preprogramme period suggests that slopes are relatively flat and not significantly different (results not shown). Fourth, we also do not consider all possible costs of smoking, for example, secondhand smoke costs are not included. Inclusion of these costs would increase the estimated ROI since reductions in smoking prevalence would increase savings resulting from secondhand smoke healthcare expenditures and mortality. Finally, our data on the SAF for healthcare expenditures are dated, though it is Florida specific.[26] While a more recent estimate of an SAF for healthcare expenditures is available for the total USA,[30] a recent estimate for Florida is not available. However, the national estimate is similar to the Florida estimate we use.

A positive ROI suggests to decision-makers that a programme or intervention is a good investment. For programme decision-makers and stakeholders, understanding state-specific ROI is critical because the available measures of costs and benefits for ROI calculations vary too widely across states to be interpreted and used by an individual state. This paper suggests that the BTFF is a good investment of public funds. In an environment, where policy-makers are faced with making difficult choices, the results of this study suggest that significant cuts in funding to the BTFF could result in additional costs in terms of healthcare expenditures and premature mortality.

Contributors JN developed the study concept and design with contributions from AJM and NM. RW, AJM and NM conducted all analyses. JN wrote the first draft of the manuscript with contributions from AJM, NM, RW, JD and LP. All authors contributed to and have approved the final manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval This study only used publicly available data with no personally identifiable information and thus does not involve research with human subjects.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available. The data we used for our study are identified in the manuscript as well as a description of the methods used. Additional details are available upon request.

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APPENDIX 1

To identify the potential control states for the analysis, we compared the Centers for Disease Control and Prevention's (CDC's) recommended funding levels for each state with the state's level of tobacco control program funding. This comparison was conducted so that states with tobacco control programs were not included as potential control states for the synthetic control group analysis. The funding thresholds selected are summarized in Table A1, and include 5%, 10%, 15%, and 20% values. These percentages indicate the actual level of funding in the state compared to the CDC-recommended funding level for the state. Operationalized, this means that for the 5% criteria, states whose funding levels exceeded 5% of the CDC-recommended funding level in any year of the post-treatment period (1999–2015) were excluded from the pool of potential control states. This exercise was repeated for 10%, 15%, and 20% funding levels. As an alternate specification, we relaxed the standards so that a state could have funding levels above the specified percentage level in some years but could not exhibit more consistent funding. For this specification, a state could have funding levels that exceeded the percentage threshold in no more than 3 of the 17 years. For this condition, states had on average 1 to 2 years of funding that exceeded the criteria level. We used the various threshold values and criteria in order to have a mix between conservative control state pools (as few as 4 states) and relaxing the criteria to include more states as potential control states (as many as 21 states).

In addition to varying the control states, we also varied the predictors that are used to select the synthetic control states in the pretreatment period. As noted in the paper, the predictors were the percentage of the population aged 18+, the percentage of the population that is male, the percentage of the population that reported making a quit attempt in the past year, the median income of the state, the poverty rate, the percentage of respondents who reported drinking in the past week, and the percentage of adults who reported exercising any in the past week. These variables were averaged over the 1991–1999 period and augmented by adding 3 years of lagged smoking prevalence: 1991, 1995, and 1998. We varied these predictors in four models. Model 1 included just the three smoking lags as the predictors. Model 2 included the smoking lags as well as the percentage of the population aged 18+, the percentage of the population that is male, and the percentage of the population who reported making a quit attempt. Model 3 included the same predictors as Model 2 plus the median income of the state and the poverty rate of the state. Model 4 included with same predictors as Model 3 plus the percentage of respondents who reported drinking in the past week and the percentage of adults who reported exercising any in the past week. Using the synth package[1], we computed the mean square predicted error for each of the model specifications and potential control states to which combination most closely matched Florida in the pretreatment period. Table A1 presents the mean squared predicted errors for the various control state combinations as well as the various model specifications. The final model used a 15% funding threshold (with no more than 3 years exceeding a funding percentage of 15%) as well as the full set of predictors for Model 4.

Table A1. Mean Squared Predicted Errors (*100) for the various model specifications

	Control States Funding Criteria							
Predictors	**5%**	**10%**	**15%**	**20%**	**5% Alternate**	**10% Alternate**	**15% Alternate**	**20% Alternate**
Model 1	1.772	1.445	1.470	1.504	1.441	1.067	1.259	0.967
Model 2	2.092	1.641	1.577	1.583	1.674	1.297	1.127	1.124
Model 3	2.140	1.518	1.599	1.338	2.020	1.222	1.045	1.110
Model 4	2.140	1.747	1.636	1.367	2.030	1.101	0.885	1.035

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Note: Model 1 includes 3 years of lagged smoking prevalence (1991, 1995, and 1998) as predictors. Model 2 includes 3 years of lagged smoking prevalence (1991, 1995, and 1998), as well as the percentage of the population aged 18+, the percentage of the population that is male, and the percentage of the population who reported making a quit attempt as predictors. Model 3 includes 3 years of lagged smoking prevalence (1991, 1995, and 1998), the percentage of the population aged 18+, the percentage of the population that is male, the percentage of the population who reported making a quit attempt as predictors, as well as the median income of the state and the poverty rate of the state. Model 4 includes 3 years of lagged smoking prevalence (1991, 1995, and 1998), the percentage of the population aged 18+, the percentage of the population that is male, the percentage of the population who reported making a quit attempt as predictors, the median income of the state, the poverty rate of the state, as well as percentage of respondents who reported drinking in the past week, and the percentage of adults who reported exercising any in the past week.

Table A2 contains the list of potential control states for the selected model and the weights that were assigned to the selected control states using Stata's *synth* package[1]. Smoking trends in Florida prior to Florida's program funding are best reproduced by a combination of Alabama (21%), Michigan (15.6%), New Jersey (31.8%), Tennessee (11.2%), and Texas (20.5%). Georgia, Illinois, Iowa, Kentucky, Missouri, Nebraska, South Carolina, and Virginia were included as potential control states but were determined by the model to be excluded when constructing a synthetic control group.

Table A2. Control states and assigned weights

State	Weight
Alabama	**21.0%**
Georgia	0%
Illinois	0%
Iowa	0%
Kentucky	0%
Michigan	**15.6%**
Missouri	0%
Nebraska	0%

New Jersey	**31.8%**
South Carolina	0%
Tennessee	**11.2%**
Texas	**20.5%**
Virginia	0%
Sum	**100.0%**

Table A3 contains a comparison of Florida and the synthetic control group on select tobacco control policies since the start of the BTFF. This table shows that the synthetic control group had higher levels of taxes and more tax increases than Florida while Florida had higher levels of Clean Indoor Air Law (CIAL) coverage in workplaces and restaurants but lower in bars than the synthetic control.

Table A3. Comparison of Florida and the synthetic control group on select tobacco control policies.

State	**CIAL Workplace**	**CIAL Restaurant**	**CIAL Bar**	**State Tax Levels**	**State Tax Increases**
Florida	76.5%	76.5%	0.0%	$0.75	1
Synthetic control weighted average	31.2%	31.1%	28.8%	$1.28	2.22

Note: CIAL = Clean Indoor Air Law

Table A4 exhibits the results from the placebo tests. We conducted placebo tests for our selected synthetic control model following the procedure outlined in Abadie et al. (2010).[2] For the placebo tests, we replace Florida with each potential donor to the synthetic control group, placing Florida in the donor pool as a potential control state, and re-estimate the synthetic control model. We then calculate the ratio of the MSPE in the post program period to the MSPE in the pre-program period. This results in 13 tests in our case. We compare the ratio of pre to post

MSPE's in Florida to those for each potential donor to the synthetic control. The post MSPE/pre MSPE ratio for Florida, a measure of the magnitude of the intervention effect, shows that 2 of the 13 potential controls would have achieved a larger effect than what was observed in Florida.

Table A4. Placebo test results.

State	Weight	MSPE (pre)	MSPE (post)	MSPE Ratio (post/pre)
Texas	20.5%	0.86	2.07	2.40
Tennessee	11.2%	1.10	1.94	1.76
Florida	N/A	0.89	1.42	1.60
Iowa	0.0%	0.74	1.18	1.58
Illinois	0.0%	0.83	1.12	1.35
Kentucky	0.0%	3.32	4.47	1.35
Michigan	15.6%	1.21	1.54	1.27
New Jersey	31.8%	2.74	2.83	1.04
Missouri	0.0%	1.88	1.91	1.01
Virginia	0.0%	1.98	1.31	0.65
Nebraska	0.0%	1.71	0.91	0.54
Georgia	0.0%	2.51	1.15	0.46
South Carolina	0.0%	2.18	0.91	0.42
Alabama	21.0%	3.19	1.35	0.42

We also conducted a sensitivity analysis (Table A5). For this we conducted the synthetic control estimation and calculated the ROI for each of 6 model specifications which had the next 6 lowest MSPE's compared to our selected model. This creates a new synthetic control group and then compares Florida to the new synthetic control created. We report the mean and median ROIs across these 6 models. This gives us 6 new ROIs and to some extent measures the sensitivity of our results to the specific model and synthetic control group we create. The results show that the ROIs would be positive and relatively large across all these different model specifications and set of different synthetic controls.

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Table A5. Results of Sensitivity Analysis

Model	Net Costs (Smoking Attributable Healthcare Savings - Program Costs)	ROI Healthcare Expenditures	SAM	YLL	Economic Costs Associated With YLL	ROI Mortality
Main Model	6,943,814,267	9.6	29,006	451,402	81,208,172,793	112.4
Sensitivity Analysis Mean	5,615,528,271	7.8	24,520	380,708	68,413,050,560	94.7
Sensitivity Analysis Median	4,109,925,658	5.7	24,520	213,908	38,178,305,228	52.9

Table A6 contains the actual adult smoking prevalence estimates for Florida from CDC's Behavioral Risk Factor Surveillance System as well as the smoking prevalence estimates for the synthetic control group.

Table A6. Prevalence estimates for Florida and synthetic control group

Year	Florida	Synthetic Control
1991	25.0%	24.1%
1992	22.7%	22.6%
1993	22.1%	21.6%
1994	23.8%	23.0%
1995	23.2%	23.1%
1996	21.8%	23.8%
1997	23.6%	23.7%
1998	22.0%	22.9%
1999	20.6%	22.8%
2000	23.2%	23.1%
2001	22.4%	23.0%

2002	22.0%	22.7%
2003	23.9%	23.0%
2004	20.2%	22.0%
2005	21.7%	21.5%
2006	21.0%	20.3%
2007	19.3%	20.1%
2008	17.5%	18.9%
2009	17.1%	19.0%
2010	17.1%	17.6%
2011	19.3%	20.6%
2012	17.7%	20.6%
2013	16.8%	18.8%
2014	17.6%	18.2%
2015	15.8%	17.6%

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Estimating Smoking-Attributable Healthcare Expenditures (SAE) in Florida

For our analysis, we examine both the direct and indirect costs associated with smoking. For direct costs, we focus on the healthcare expenditures in Florida associated with smoking-related illness. The Centers for Medicare and Medicaid Services (CMS) provides data on nominal annual total healthcare expenditure data by state of residence for the years 1991 through 2014 online. We downloaded data on total healthcare expenditures in Florida for 1999 through 2014 from the CMS website.[3] We estimated total healthcare expenditures in Florida in 2015 based on the average annual growth in total healthcare expenditures in Florida over the last 10 years of available CMS data (2004–2014). We adjusted nominal annual total healthcare expenditures in Florida for the years 1999 through 2015 for inflation using the national Consumer Price Index (CPI) for medical care produced by the Bureau of Labor Statistics.[4] All healthcare expenditures presented in this paper are expressed in real, inflation-adjusted, 2015 dollars

To estimate the healthcare expenditures associated with smoking, we also used a Smoking-Attributable Fraction (SAF) approach. The SAF for smoking-attributable healthcare expenditures represents the fraction of total healthcare expenditures in Florida that were due to smoking-related illness. We obtained estimates of the SAF of healthcare expenditures in Florida in 1993 from Miller et al.[5] They calculated SAFs based on a 2-part model of annual individual expenditures estimated using the 1987 National Medical Expenditure Survey.

Because new estimates of SAF specific to Florida are not readily available and are difficult to obtain given the data requirements for producing such estimates, we adjusted the 1993 SAF for Florida to account for changes in adult smoking prevalence in Florida over the years from 1994 through 2015. Based on year-over-year relative changes in adult smoking prevalence in Florida for the years 1994 through 2015, we adjusted the 1993 SAF for Florida using the formula below:

$$SAF_{Florida} = SAF_{Florida\ (Previous\ Year)} \times \left(1 + \text{Relative \% Change in Annual Smoking Prevalence}\right)$$

The SAF estimates reported by Miller et al.[5] exclude healthcare expenditures for dental care. We follow that approach and exclude healthcare expenditures for dental services from our analysis. Adult smoking prevalence estimates for Florida for the years 1993 through 2015 were obtained from the CDC's Behavioral Risk Factor Surveillance System (BRFSS).[6].

We calculated annual smoking-attributable healthcare expenditures in Florida by multiplying inflation-adjusted total healthcare expenditures in Florida by our annual estimates of the SAF for healthcare expenditures in Florida.

$$SAE_{Florida} = Total\ Healthcare\ Expenditures_{Florida\ (Real\ \$\ 2015)} \times SAF_{Florida}$$

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Estimating Smoking-Attributable Mortality (SAM) and Smoking-Attributable Years of Life Lost (YLL) in Florida

We obtained annual estimates of both total and smoking-attributable mortality as well as average remaining life expectancy in Florida for the years 1999 through 2015 from the 2017 Global Burden of Disease (GBD) study. The 2017 GBD study, produced by the Institute for Health Metrics and Evaluation (IHME), serves as a tool for estimating morbidity and mortality from a broad spectrum of diseases and risk factors across 195 countries and territories from 1990 through 2017. GBD data are collected and analyzed by a consortium of over 3,000 researchers in more than 130 countries. Data capture premature mortality and disability from more than 300 diseases and injuries by geography, year, age, and sex. These data are accessible on the IHME's Global Health Data Exchange (GHDx) website: http://ghdx.healthdata.org/gbd-results-tool. We downloaded GBD data on total mortality, smoking-attributable mortality (SAM), and average remaining life expectancy by sex, 5-year age group, and cause for Florida for the years 1999 through 2015 from the IHME website for the 2017 GBD study results.[7] Our analytic data set includes GBD data for 33 different communicable and non-communicable diseases associated with smoking-attributable mortality in Florida.

Using GBD on total and smoking-attributable mortality in Florida, we derive the Smoking-Attributable Fraction (SAF) of mortality associated with smoking in Florida. The SAF for smoking-attributable mortality represents the fraction of total deaths in Florida that were due to smoking. We derive annual SAFs for each sex, 5-year age group, and each of the 33 specific causes included in our analytic data. We estimate the SAFs for mortality using the following formula:

$$SAF_{Sex,Age,Cause} = \frac{\text{Smoking-Attributable Deaths}_{Sex,Age,Cause}}{\text{Total Deaths}_{Sex,Age,Cause}}$$

We calculated smoking-attributable years of life lost (YLL) using GBD data on smoking-attributable mortality (SAM) in Florida as well as GBD data on average remaining life expectancy by sex and 5-year age group. Average remaining life expectancy is the number of additional years a person is expected to live at a given age, assuming he or she will experience the age-specific mortality rate observed in a given year throughout the rest of his or her lifetime. The GBD data on average remaining life expectancy is reported by sex and 5-year age groups. The average remaining life expectancy associated with each 5-year age group (e.g. 50 to 54-year-olds) is equal to the average remaining life expectancy at the starting year of the age group. The GBD data on average remaining life expectancy is expressed with decimals to represent fractional years of average remaining life expectancy. We used a floor function and converted the average remaining life expectancy for each sex and 5-year age group to the nearest whole number. To calculate YLL, we multiply the annual number of smoking-attributable deaths for each sex and 5-year age group by the average remaining life expectancy for that sex and 5-year age group.

$$\begin{aligned} &\text{Smoking-Attributable Years of Life Lost (YLL)}_{Sex,Ag} \\ &\quad = \text{Smoking-Attributable Deaths}_{Sex,Age} \\ &\quad \times \text{Average Remaining Life Expectancy}_{Sex,Age} \end{aligned}$$

Estimating the Economic Value of Premature Mortality Due to Smoking in Florida

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The measure of indirect costs associated with smoking in Florida that we examine in this study is the economic value of life lost due the premature mortality from smoking-attributable deaths. To calculate the economic value of life lost due to premature mortality, we calculated the present value for each year of life lost by age of death and then multiplied that currency amount by the number of smoking-attributable deaths in each age group. We calculated the economic value of premature mortality due to smoking in Florida using two different methods: a per capita GDP approach for the Value of a Life Year (VLY) and a Value of a Statistical Life Year (VSLY) approach. Both approaches consist of placing an economic (e.g. currency) value on the years of life lost (YLL) due to premature mortality associated with smoking. The number of smoking-attributable years of life lost (YLL) due to premature mortality is the same for both calculations. However, the currency value used to place an economic value of life year lost in the two calculations differs.

Value of a Statistical Life Year (VSLY) Approach: We used a life-year value of $200,000 (the midpoint of 3 VSLY estimates used in the literature).[8-10] We updated this for inflation using the Consumer Price Index (CPI) to $235,135 in real, inflation-adjusted, 2015 dollars. Consistent with the US Food and Drug Administration practice, we used a social discount rate of 3% in calculating life-year values.[11]

Estimating the Impact of the Florida Tobacco Control Program on Smoking-Attributable Mortality and Costs

For this analysis, we are assessing the impact of the Florida Tobacco Control Program by estimating what adult smoking prevalence in Florida would have been from 1999 through 2015 if the Florida Tobacco Program had not existed. All of the smoking-attributable mortality (SAM), years of life lost (YLL), healthcare expenditures, and economic value of premature mortality outcomes for Florida are all modeled and estimated as a function of adult smoking prevalence in Florida. To estimate what impact the Florida tobacco control program has had on these smoking-attributable outcomes, we estimate what those outcomes would have been in adult smoking prevalence in Florida over the years from 1999 through 2015 would have remained at the levels estimated by our "Synthetic Control Group" instead of the historical smoking prevalence observed in Florida over those years. The difference between the smoking-attributable outcomes in Florida under the Synthetic Control Group and the historical adult smoking prevalence observed in Florida is the estimated impact that the Florida Tobacco Control Program has had on smoking-attributable mortality (SAM), smoking-attributable years of life lost (YLL), smoking-attributable healthcare expenditures (SAE), and the economic value of premature mortality due to smoking.

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To estimate what smoking-attributable outcomes would have been in Florida if annual adult smoking prevalence in Florida over the years from 1999 through 2015 had been at the levels estimated by the "Synthetic Control Group", we calculate separate annual SAFs for smoking-attributable mortality (SAM) and smoking-attributable healthcare expenditures (SAE) in Florida. We do this by adjusting the original SAFs for our analysis by the relative annual difference in smoking prevalence in Florida between the Synthetic Control Group and the historical adult smoking prevalence observed in Florida. The annual SAFs for the Synthetic Control Group are calculated as follows:

$$SAF_{Synthetic\ Control} = SAF_{Florida} \times [1 + \Delta Prevalence]$$

$$SAF_{Syntheti\quad Control} = SAF_{Florida} \times \left[1 + \frac{(Prevalence_{Synthetic\ Control} - Prevalence_{Florida})}{Prevalence_{Florida}}\right]$$

We calculate annual SAFs separately for smoking-attributable mortality (SAM) and smoking-attributable healthcare expenditures (SAE). The annual SAFs for smoking-attributable mortality for the Synthetic Control Group scenario are calculated separately for each sex, 5-year age group, and specific disease included in our analytic data. The annual SAFs for smoking-attributable healthcare expenditures are calculated at the state level and result in a single SAF per year.

We use the SAFs for the Synthetic Control Group to calculate smoking-attributable mortality (SAM) and smoking-attributable healthcare expenditures (SAE) in Florida over the years from 1999 through 2015 that would have been expected had adult smoking prevalence in Florida been equal to the level for the Synthetic Control Group over those years. We calculated smoking-attributable mortality for the Synthetic Control Group by multiplying annual estimates of total mortality in Florida by sex, age group and cause from the GBD study by the adjusted SAFs that we calculated for the Synthetic Control Group. We calculated smoking-attributable healthcare expenditures for the Synthetic Control Group by multiplying annual estimates of total health expenditures in Florida by the adjusted SAFs that we calculated for the Synthetic Control Group. We calculated smoking-attributable years of life lost (YLL) and the economic value associated with premature mortality due to smoking in Florida for the Synthetic Control Group using the same methods as described earlier in this section.

To estimate the impact of the Florida Tobacco Control Program on smoking-attributable mortality, years of life lost (YLL), healthcare expenditures, and the economic value of premature mortality due to smoking in Florida over the years from 1999 through 2015, we take the difference in each of those smoking-attributable outcomes in Florida between the Synthetic Control Group scenario and the estimates for Florida based on historical estimates of adult smoking prevalence in Florida.

$$Program\ Impact_{Outcome} = Outcome_{Synthetic\ Control} - Outcome_{Florida}$$

Where Outcome =

- Smoking-Attributable Mortality (SAM)

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- Smoking-Attributable Years of Life Lost (YLL)
- Smoking-Attributable Healthcare Expenditures (SAE)
- Economic Value of Years of Life Lost Due to Premature Mortality from Smoking

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