Budgetary impact from multiple perspectives of sustained antitobacco national media campaigns to reduce the harms of cigarette smoking

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ABSTRACT

Background High-intensity antitobacco media campaigns are a proven strategy to reduce the harms of cigarette smoking. While buy-in from multiple stakeholders is needed to launch meaningful health policy, the budgetary impact of sustained media campaigns from multiple payer perspectives is unknown.

Methods We estimated the budgetary impact and time to breakeven from societal, all-payer, Medicare, Medicaid and private insurer perspectives of national antitobacco media campaigns in the USA. Campaigns of 1, 5 and 10 years of durations were assessed in a microsimulation model to estimate the 10 and 20-year health and budgetary impact. Simulation model inputs were obtained from literature and both pubic use and proprietary data sets.

Results The microsimulation predicts that a 10-year national smoking cessation campaign would produce net savings of $10.4, $5.1, $1.4, $3.6 and $0.2 billion from the societal, all-payer, Medicare, Medicaid and private insurer perspectives, respectively. National antitobacco media campaigns of 1, 5 and 10-year durations could produce net savings for Medicaid and Medicare within 2 years, and for private insurers within 6–9 years. A 10-year campaign would reduce adult cigarette smoking prevalence by 1.2 percentage points, prevent 23 500 smoking-attributable deaths over the first 10 years. In sensitivity analysis, media campaign costs would be offset by reductions in medical care spending of smoking among all payers combined within 6 years in all tested scenarios.

Conclusions 1, 5 and 10-year antitobacco media campaigns all yield net savings within 10 years from all perspectives. Multiyear campaigns yield substantially higher savings than a 1-year campaign.

INTRODUCTION

Cigarette smoking remains the single largest cause of preventable disease and death in the USA, accounting for more than 480 000 deaths each year and $168 billion in annual healthcare expenditures, with more than 60% of the spending being paid by public programmes, including Medicare and Medicaid.[1 2] Approximately 34 million adults continue to smoke cigarettes,[3] and the prevalence of smoking remains high among subgroups such as American Indian/Alaska Natives (24.0%), adults insured by Medicaid (24.5%) and those living with a disability (20.7%).[3]

Sixty-eight per cent of smokers report that they want to quit permanently, and more than 50% report making a quit attempt during the past year.[4] Tobacco control ad campaigns, especially campaigns using television ads, are effective in increasing the number of smokers who call telephone quitlines.[5] These ads can also be effective in reducing cigarette smoking by motivating smokers to quit.

New quit attempts will spur additional use of covered smoking cessation treatments in quitters that avail themselves of such treatments. However, the budgetary impact may be markedly different across payers—private insurers, Medicaid and Medicare, who serve populations with substantially different age distributions and smoking status.[3 6] Furthermore, given the prolonged trajectory of smoking-related disease, the financial benefit from reduced smoking-attributable medical care may be realised by a different insurer than the one who incurred the expense of a quit as former smokers are likely to change insurance types over their lifetimes. Budgetary impacts can illuminate the payers who may benefit sufficiently to support preventive interventions including quantifying the size of incentives that may spur stakeholders with different financial perspectives to support a prevention programme.[7]

In 2012, the Centers for Disease Control and Prevention (CDC) launched the first federally funded national antismoking media campaign, Tips From Former Smokers (Tips), with focused television ads that targeted adult smokers for 12 consecutive weeks.[8] The ads warned smokers about the health effects of smoking and referred smokers who want help quitting to the 1-800-QUIT-NOW national quitline portal and the National Cancer Institute's cessation website, www.smokefree.gov.[8] Calls to the quitline increased 132% and 428%, respectively, during the 2012 Tips campaign compared with the same period in the prior year.[9]

A simulation analysis based on the first wave of the Tips campaign found that it prevented 17 109 deaths while incurring costs of $480 per quitter and $2819 per death averted.[10] The analysis was from the funding agency's perspective, it did not account for expenditures on smoking cessation medications or savings from averted medical care expenditures, and estimates from other perspectives were beyond the study's scope. Media campaign costs, population health benefit and the net budgetary impact on public insurance programmes are important

considerations in proposing a government-financed national media campaign.

The current study used a microsimulation model to project the health and budgetary impacts of a national media campaign from societal and multiple US health insurance payers' perspectives. The impacts are estimated over 10 and 20 years for continuous campaigns lasting 1, 5 and 10 years to specifically determine whether and when the cumulative medical expenditure offsets from improved health outweigh the cumulative costs of implementing a campaign from multiple perspectives. The results inform stakeholder discussions, programmatic decisions and budget planning.

METHODS

A model that simulates tobacco-related behaviour of individuals representative of the US population was used to forecast the budgetary impact of a national antitobacco media campaign. We compare campaign scenarios with the status quo to estimate the incremental impact of layering a national media campaign on top of existing tobacco control initiatives. Results reported from the perspective of payers include direct medical expenditures on smoking cessation medications and smoking-attributable medical care. For the societal perspective, we add direct costs of a media campaign plus productivity gains. The simulated media campaign includes expenditures for annual evaluation and strategic adjustments to help sustain effectiveness over time. Analyses were conducted with a 10-year horizon for consistency with US government legislative analysis[11] and with a 20-year horizon to explore longer term impacts. For the budgetary analysis of the base case, results are not discounted to present value. Key model parameters are summarised in table 1.

Media campaign intervention

The national media campaign modelled meets CDC's best practices guideline of minimum media purchases of 1200 gross rating points (GRP) in the first quarter of each year and 800 GRPs in subsequent quarters.[12] Assumptions about the campaign intensity, effectiveness and costs are aligned to be internally consistent with parameters obtained from published reports of the 2012 Tips campaign.

The Tips campaign provides the only US evidence of a national media campaign focused on promoting tobacco cessation among adults. The Tips campaign increased quit attempts 12% based on surveys that were administered to adults shortly after the 12-week Tips campaign in 2012.[13] We applied the same effect size to an extended 12-month campaign for each age, sex and race-ethnic category. For example, if 50% of Hispanic male smokers aged 18–24 years attempt to quit each year in the status quo scenario, this quit rate would increase to 56% (0.50*1.12) in the media campaign scenario.

The 2012 campaign resulted in more than 1000 GRPs of combined paid and earned media.[13] We applied the 12% effectiveness estimate of national media campaign effectiveness to a full-year campaign with quarterly purchases of 1200, 800, 800 and 800 GRPs. In doing so, we assume that purchases of 800 GRPs in subsequent quarters would sustain the short-term impact. By using the Tips-based effectiveness estimate, we assume that a 12% relative increase in quit attempts translates to a 12% relative increase in quits at the end of 1 year. For example, a smoker with a 10% probability of cessation at the end of a year without a media campaign would have an 11.2% chance of cessation at the end of year with a media campaign. We also

Table 1 Selected model parameters

Model parameter	Value		Source
Youth smoking prevalence at baseline, ages 9–17*	5.3%		2011 YRBS,[46] calibrated
Adult smoking prevalence at baseline, ages 18+*	17.8%		2013 NHIS[18]
Adult cessation rate without media campaign*	7.1%		2013 NHIS[18]
Relative risk of cessation with media campaign	1.2		McAfee *et al*[13]
Selected annual relapse rates by year since quit after 6 months of continuous cessation†			DHHS,[19] Wetter *et al*,[20] Herd *et al*,[21] Hughes *et al*,[22] Gilpin *et al*[23]
1st year	18.9%		
2nd year	13.3%		
5th year	5.6%		
10th year	0.4%		
Proportion of quitters who use smoking cessation medications*			Based on 2010 NHIS data,[47] see online supplementary file 1
Over-the-counter NRT	19.2%		
Prescription NRT	0.6%		
Bupropion	2.1%		
Varenicline	7.2%		
Average annual insurer expenditure of cessation medications‡	**Medicaid**	**All other insurers**	MarketScan databases, see text
Over-the-counter NRT	$234	$199	
Prescription NRT	$1347	$1170	
Bupropion	$118	$80	
Varenicline	$771	$686	
Annual per-person medical expenditures of current and former smokers§	See online supplementary material 1, table 4		Linked NHIS-MEPS data[48]
Annual cost of media campaign ($ millions)			Xu *et al*[10]
Creative development	$6.9		
Media purchases	$118.0		
Evaluation	$3.2		
Total	$128.1		
Discount rate in base case	0%		
Year of dollar values	2015		CPI[49] and MCPI[50]

*Average shown. Varies by age, sex and race/ethnicity. Adult prevalence and cessation rates also vary by educational status and insurance type. Smoking medication use also varies by insurance type.
†Varies as a continuous function of time since quit.
‡Varies by age, sex, insurance type and smoking status.
§Varies by age, sex, and smoking status. Also varies by time since quit for former smokers.
CPI, Consumer Price Index; DHHS, Department of Health and Human Services; MCPI, Medical Care Price Index; MEPS, Medical Expenditure Panel Survey; NHIS, National Health Interview Survey; NRT, nicotine replacement therapy; YRBS, Youth Risk Behavior Survey.

assumed that relapse rates in subsequent years are the same with and without a media campaign.

Media campaign costs

Xu *et al* reported that the 2012 Tips campaign cost $47.9 million. This included $6.7 million for creative development, $38.1 million for media buys for 12 weeks and $3.1 million for subsequent evaluation.[10] In this analysis, we included these development, evaluation and media costs for the first quarter plus another $25.4 million (=$38.1 million × (800/1200)) for 800 GRP media purchases in the second, third and fourth quarters.

From the perspective of insurers, media campaigns initially increase quit attempts and associated costs of covered smoking cessation treatments. However, expenditures on cessation treatments will decline over time in the media campaign scenarios as smoking prevalence falls. These expenditures were estimated from the MarketScan database for 2014, including payer expenditures and patient out-of-pocket costs. Medicaid expenditures represent the average for beneficiaries in the anonymous states included in the MarketScan Medicaid database. Medication expenditures borne by both private insurers and Medicare in the model represent the average borne by private insurers for those covered by employer-sponsored health insurance included in the MarketScan Commercial Encounters database.

Summary of the analytical model. ModelHealth: Tobacco

The analysis was conducted using the HealthPartners Institute ModelHealth: Tobacco microsimulation model. ModelHealth: Tobacco is a state-transition Markov microsimulation, constructed using TreeAge PRO 2015.[14] We describe the essential elements of the model here and provide additional detail in online supplementary material 1.

The model's cycle length is 1 year. At model initiation, each simulated person was randomly assigned an age, sex and race-ethnicity according to probabilities derived from the Current Population Survey (CPS), and these demographics were used to assign lifetime education status.[15] An insurance module assigns each simulated individual to one of five primary payer categories: uninsured, Medicaid, Medicare (including dual eligible), private or other. Initial insurance status is determined by a multinomial logistic regression accounting for age, sex, ethnicity, education, poverty status, disability status and labour force participation using pooled data from 2009 to 2012 CPS.[15] The 3-year longitudinal sample of the 2008 cohort of the Survey of Income and Program Participation was analysed to define insurance status transitions.[16]

A behavioural module initially assigns one of three smoking states to each individual: never, current or former, with current and former smokers having smoked 100 or more cigarettes in their lifetimes.[17] The likelihood of a smoking state was determined by a set of multinomial risk equations using 2013 National Health Interview Survey (NHIS) data[18] adjusting for age, sex, ethnicity and lifetime educational attainment for ages 25 years or older. During each annual cycle, never smokers younger than 25 may initiate smoking, current smokers may quit and former smokers may relapse. Never smokers 25 years or older remain never smokers for the rest of their life. Relapse probabilities vary with time since quit based on longitudinal studies.[19–23]

Smoking behaviour determines the risk of smoking-attributable disease, smoking-attributable medical care utilisation and smoking-attributable productivity loss in the health impact module. The model includes smoking-attributable diseases identified in the updated Smoking-Attributable Mortality, Morbidity, and Economic Costs estimates.[1] Cancer-relative risks were applied to incidence and case-fatality rates estimated using SEER*Stat.[24] For other diseases, the model tabulates hospitalisations obtained from the National Hospital Discharge Survey[24] and fatality rates obtained from compressed mortality files.[25] The tabulation of event rates by age, sex and smoking status is described in the online supplementary file 1.

Disease expenditures and productivity

We estimated smoking-attributable medical expenditures from the Medical Expenditure Panel Survey (MEPS) linked to the NHIS[26] using standard econometric techniques as detailed in online supplementary material 1, with results shown in table 4 of the online supplementary material 1. Estimates using MEPS or other claims data usually reveal higher utilisation among former than current smokers, likely due to quitting smoking after disease symptoms arise.[27–30] To estimate the expenditures of former smokers who quit proactively, we calculated their smoking-attributable medical expenditures as an exponentially decaying portion of smoking-attributable expenditures incurred by age and sex-matched current smokers following the Congressional Budget Office report of a federal excise tax increase.[11]

The simulation model incorporated three sources of productivity loss: premature mortality; absenteeism, or days of lost productivity not associated with exit from labour force; and presenteeism, or being at less-than-full working capacity during days of work. The model values productivity of each year of life using estimates by age group reported by Grosse *et al*[31] updated for changes in national average of employee earnings and benefits.[32] We included absenteeism and presenteeism costs from smoking estimated by Mitchell and Bates in 1 million employees for 13 conditions and four risk factors.[33]

RESULTS

The simulation predicts that each type of insurer will experience net savings in the first 10 years after a media campaign starts, with cumulative reductions in medical care expenditures for current and former smokers exceeding increased expenditures on smoking cessation treatments (table 2). Projected savings for Medicaid programmes exceed $3 billion with the 5 and 10-year campaigns, larger than for Medicare and private insurers. The predicted net savings from reduced smoking-attributable medical expenditures for all insurers during the first 10 years reach $1.7, $5.6 and $6.4 billion for 1, 5 and 10-year campaigns, respectively. Direct costs from the societal perspective include media campaign costs, smoking cessation medication expenditures of insurers and patient out-of-pocket costs. These expenditures are more than offset by the reduced smoking-attributable medical expenditures within 10 years, generating net savings of $1.6, $5.0 and $5.1 billion by campaign duration. When adding the indirect productivity gains for the societal perspective, the cumulative net direct and indirect savings over 10 years are projected to be $3.1, $9.4 and $10.4 billion by campaign duration.

For each perspective, table 3 shows the predicted breakeven year, when the cumulative costs associated with the media campaign are outweighed by cumulative reduced medical spending on current and former smokers. Medicaid and Medicare could recoup initial expense of increased quit attempts in the second year for campaigns of each duration. The breakeven point for private payers is predicted to occur in years 6, 7 and 9 for campaign durations of 1, 5 and 10 years, respectively. From societal perspectives, the breakeven point is predicted to occur in 5 or fewer years for each campaign duration.

Table 2 A 10 and 20-year difference in economic outcomes from the insurer and societal perspectives by duration of media campaign compared with no campaign ($ millions)

	Net medical expenditure* by primary insurer			Economic outcomes from societal perspective				
Media campaign duration	Private insurers	Medicaid	Medicare	Media campaign costs	Net medical expenditures*	Change in productivity losses	Net direct costs† (societal perspective)	Net direct and indirect costs‡ (societal perspective)
	10 years after campaign start							
1 year	−170	−870	−360	130	−1700	−1570	−1570	−3140
5 years	−350	−3000	−1200	640	−5600	−4420	−4960	−9370
10 years	−180	−3600	−1370	1280	−6360	−5320	−5080	−10 400
	20 years after campaign start							
1 year	−920	−1690	−1190	130	−4470	−4600	−4350	−8940
5 years	−3600	−7190	−4550	640	−18 110	−13 970	−17 460	−31 430
10 years	−4970	−11 870	−6920	1280	−28 140	−22 670	−26 860	−49 530

*Include the expenditures of smoking cessation treatments and expenditures of smoking-attributable illness.
†Includes net medical expenditures plus media campaign costs.
‡Includes net medical expenditures, media campaign costs and productivity gains.

These financial effects are the result of predicted changes in smoking prevalence shown in figure 1 and accompanied by health benefits shown in table 4. Ten years after the start of an antitobacco media campaign, adult cigarette smoking prevalence is predicted to decrease by 0.1, 0.4 and 1.2 percentage points with 1, 5 and 10-year campaigns compared with the no campaign scenario, respectively. The predicted health benefits during the first 10 years following the start of 5 and 10-year campaigns will be four to six times larger than the benefits of a 1-year campaign. Health benefits are projected to continue to accumulate after a campaign ends as former smokers' risk progressively decreases. The potential for long-term impact can be seen in table 4 by comparing the health impact across 10 and 20-year horizons. The model assumes no impact on cessation rates after a campaign ends, yet the projected benefits to former smokers continue to accumulate and become 50%–300% higher over 20 years compared with the first 10 years.

Sensitivity analyses for a 10-year antitobacco media campaign are summarised in online supplementary material 2. We found that both campaign effectiveness and campaign costs are influential variables, savings vary by more than 50% when campaign effectiveness is changed by 50%, but vary by 20% or less when changing campaign costs by 50%. Net savings during the first 10 years were maintained in all scenarios.

We explored applying a 3% annual discount rate to all costs and benefits to calculate their present value at the start of the media campaign. In multivariate sensitivity analysis, net direct savings of $980 million are still realised over the duration of a 10-year campaign when discounting by 3% while simultaneously increasing media campaign costs by 50% and decreasing media campaign effectiveness by 50%.

Table 3 Number of years until cumulative economic benefits exceed campaign costs by perspective

Media campaign duration	Private payers	Medicaid*	Medicare	Societal (direct costs only)†	Societal (direct and indirect costs)‡
1 year	6	2	2	3	3
5 years	7	2	2	5	4
10 years	9	2	2	5	4

*Cost savings to Medicaid include both federal and state portions.
†Includes all direct costs: media campaign costs, cessation treatment expenditures and smoking-attributable medical expenditures.
‡Includes all direct costs plus productivity changes.

DISCUSSION

Using a simulation model that weighs costs and benefits from multiple perspectives we found that it is likely that private payers, Medicare and Medicaid would all realise net savings within 10 years when a national, sustained antitobacco media campaign is deployed. From the societal perspective, the savings from reduced medical care expenditures from quitting smoking are predicted to exceed media campaign development, implementation and evaluation costs. When productivity gains and health benefits from helping smokers quit through a national media campaign are considered the net savings increase. Findings from the first Tips campaign indicated that it reached nearly 80% of US smokers[9] and was effective in increasing population-level quit attempts by 12%.[13] That analysis undertaken from the funding agency's perspective found that the first wave of the Tips campaign cost $480 per quitter and $2819 per death averted without including offsets from reduced spending on medical care.[10] Building on previous findings by factoring in the costs of the campaign, its annual evaluation and retooling, expenditures on smoking cessation treatments and reduced medical spending

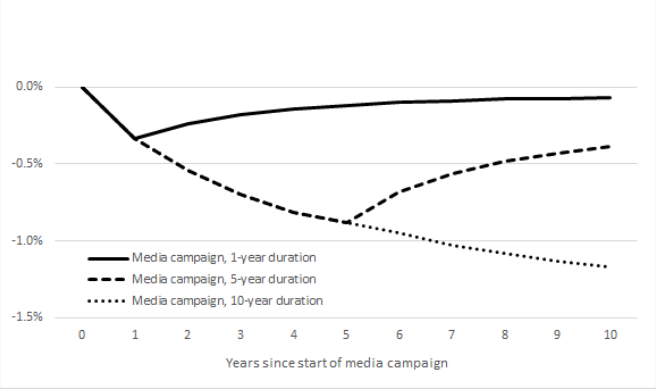

Figure 1 Percentage point difference in cigarette smoking prevalence, media campaign scenarios compared with no campaign, US adults aged 18+.

Table 4 A 10 and 20-year cumulative difference in health events by duration of media campaign. Media campaign compared with no campaign. US adults

Media campaign duration	Cancer cases	CVD and diabetes hospitalisations	Respiratory disease hospitalisations	Deaths
During the first 10 years from campaign start				
1 year	−6700	−41 400	−17 700	−4600
5 years	−23 800	−172 100	−72 500	−16 800
10 years	−39 300	−251 600	−98 700	−23 500
During the first 20 years from campaign start				
1 year	−11 000	−60 900	−28 000	−8800
5 years	−39 900	−278 100	−117 300	−32 300
10 years	−81 300	−472 400	−186 400	−65 200

CVD, cardiovascular disease.

(as appropriate for each perspective) we found that a sustained national media campaign would be cost saving in 10 years or less from multiple perspectives, including insurance payers and the societal perspective.

The overall savings for Medicaid are projected to be larger than Medicare savings in the 20 years after a campaign starts, even though older current and former smokers have higher per-person smoking-attributable expenditures than their younger counterparts. This finding might be attributed to: Medicaid participants having substantially higher per-person smoking-attributable expenditures than Medicare participants for age and sex-matched groups (online supplementary material 1, table 4); and, the simulations predicting that there will be 50% more quits attributable to media campaigns among Medicaid participants than among Medicare participants, due primarily to the higher smoking prevalence in Medicaid. Over time, most young quitters will age into Medicare and produce greater savings for the Medicare programme.

The cost savings to Medicaid reflect both state and federal portions. The federal share of these savings can be approximated as 55% of this total.[34] The projected medical care savings to either Medicare or the federal portion of Medicaid exceed the costs of 1, 5 and 10-year campaigns with the breakeven occurring within 2 years. The cost savings occurring to any one payer are not all attributable to quits which occur while the member has that type of primary insurance. For example, by reaching a broad population, a media campaign may induce a Medicaid-insured smoker to quit before becoming privately insured, or a privately insured smoker to quit before enrolling in Medicare.

A review for the Community Preventive Services Task Force found short-term campaigns to be cost saving.[5] Although prior estimates of multiyear campaigns have not reported economic outcomes, our estimated impacts on smoking prevalence are consistent with the few other simulation studies that examined multiyear antismoking media campaigns. Levy *et al* estimated that a multiyear mass media campaign might reduce adult smoking prevalence by 0.7 percentage points over 12 years.[35] Our estimates suggest that adult cigarette smoking prevalence after 10 years would be 1.2 percentage points lower. Although Levy *et al* also used a 12% estimate of campaign effectiveness, they started with a lower baseline cessation rate based on 2003 smoking behaviours, employed a 10% annual decay in media campaign effect and assumed a 9% increase in cessation treatments with the media campaign. Our estimates are also consistent with Yang *et al*'s recent estimate that a 5-year media campaign would reduce smoking prevalence among TRICARE Prime beneficiaries by 0.98 percentage points in the fifth year.[36] In ModelHealth: Tobacco, the TRICARE population is folded into the 'other insured' category. In our simulation, a 5-year campaign reduces smoking prevalence among the other insured category by 1.23 percentage points in the fifth year (not shown).

Simulations can be helpful to decision-making when outcomes cannot be practically observed in a controlled study. However, simulation results will likely differ from reality. Simulation models are limited by their inputs and by using relatively simple mathematical structures to approximate complex real-world behaviours and events. At the time smoking behaviour in the model was last updated, the most recent available smoking prevalence data were from 2013. This produces a higher baseline smoking prevalence in the model (17.8% based on 2013 data) than rates indicated by the most recent NHIS (15.5% in 2016). As a result, the impact of media campaigns estimated by the model could be higher than would be expected for a media campaign that started in 2016. Prevalence rates may also be impacted by the model's relapse curve. Due to limited data, we applied the same relapse curve described in online supplementary material 1 to all quits, regardless of the year of the quit or whether the quit was prompted by a media campaign.

For this analysis, media campaign effectiveness was extrapolated from the estimated number of quit attempts observed in the 12-week 2012 Tips campaign to 1-year and multiyear campaigns. However, the effective cessation effect—a relative risk of 1.12—is in line with a conservative subset of studies included in the Community Guide review. The relative risk of cessation is 1.18 when averaged across four studies[37–40] that represent varying levels of media campaign intensity and excludes studies limited to self-selected quitline callers and estimates based on recollection of media campaign exposure. Evidence from the literature suggests that the impact of media campaigns is short lived.[41–43] Thus, Levy *et al* incorporated a decay effect by reducing media campaign effectiveness by 10% in each successive year,[35] producing a more conservative estimate. Since we found no evidence that effectiveness waned with sustained media campaigns we did not include a decay effect in our model. These different assumptions, in part, explain the difference in our findings and Levy's findings. While we did not model a decay effect, we did include annual evaluation and creative development costs to allow for strategic adjustments to media campaign messaging and targeting to maintain effectiveness over time. In sensitivity analysis, 50% lower media campaign effectiveness still yielded net savings. Furthermore, the finding of net savings is robust to simultaneous large increases in media campaign costs and large decreases in campaign effectiveness.

The exponential relationship of time since quit and the smoking-attributable medical expenditures of former smokers influences the timing of savings and the magnitude of net savings within 10 and 20 years. The relationship is based on a review of the decline in mortality rates after quitting that the Congressional Budget Office applied to both health and financial benefits of quitting.[11] Its application to medical expenditures may lead to biased estimates of the timing of savings.

Another limitation is that the smoking-attributable medical expenditures by primary payer used in the analyses reflect all smoking-attributable medical spending for patients. This includes non-reimbursed spending, such as patient copays and deductibles, as well as other payments from secondary insurer coverage. Therefore, the net medical savings by primary payer somewhat overstate the savings from the perspective of a particular payer. However, the sensitivity analysis indicates that the conclusion of cost savings within 10 years is robust to a range of patient payments.

Indirect evidence indicates that the 2012 Tips campaign decreased youth susceptibility to initiate smoking.[44] Youth effects are not included in the reported results and would have little influence on the 10 and 20-year estimates because the full effect of smoking-related disease, disability and death does not manifest for several decades.[45] Over the long term, preventing youth initiation in a multiyear campaign could have important additional benefits.

CONCLUSIONS

The findings add to the literature by estimating the projected health and budgetary impact of a longer duration national antitobacco mass media campaign. We project that combined healthcare cost savings for all payers from a national media campaign that is designed to motivate smokers to quit and to direct those who want help in quitting to cessation assistance, will more than offset campaign costs within 5 years. In our analyses, 1, 5 and 10-year antitobacco media campaigns all yield net cost savings within 10 years. Multiyear antitobacco media campaigns yield substantially higher rates of population health benefits and cost savings than a 1-year campaign.

What this paper adds

- Observation of short-duration antitobacco media campaigns demonstrates that they increase smoking cessation among adults and they have been found to be cost saving.
- The financial impact of antitobacco media campaigns from the perspectives of private and public payers of medical care is unknown.
- The impact of contiguous, long-duration campaigns has not been observed.
- This study provides estimates of 10 and 20-year impacts of sustained antitobacco media campaigns.
- We report budgetary impact and the time to breakeven from the perspective of US private insurers, Medicaid, Medicare and the society as a whole.

Correction notice This paper has been updated since first published to correct author name 'Steven P Dehmer' and revise Table 4.

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REFERENCES

1 U.S. Department of Health and Human Services. *The health consequences of Smoking—50 years of progress: a report of the surgeon general, 2014. 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*, 2014.
2 Xu X, Bishop EE, Kennedy SM, *et al*. Annual healthcare spending attributable to cigarette smoking: an update. *Am J Prev Med* 2015;48:326–33.
3 Wang TW, Asman K, Gentzke AS, *et al*. Tobacco product use among adults - United States, 2017. *MMWR Morb Mortal Wkly Rep* 2018;67:1225–32.
4 Babb S, Malarcher A, Schauer G, *et al*. Quitting Smoking Among Adults - United States, 2000-2015. *MMWR Morb Mortal Wkly Rep* 2017;65:1457–64.
5 Guide to Community Preventive Services. Reducing tobacco use and Secondhand smoke exposure: Mass-Reach health communication interventions, 2013. Available: http://www.thecommunityguide.org/tobacco/massreach.html [Accessed 10 Feb 2014].
6 State Health Facts. Health coverage and uninsured, 2019. Available: https://www.kff.org/state-category/health-coverage-uninsured/health-insurance-status/ [Accessed 17 Oct 2019].
7 Meltzer D. Does prevention pay? *Med Care* 2015;53:291–2.
8 Office on Smoking and Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention. Tips from former smokers, 2012. Available: https://www.cdc.gov/tobacco/campaign/tips/index.html [Accessed 12 Aug 2018].
9 Centers for Disease Control and Prevention (CDC). Increases in quitline calls and smoking cessation website visitors during a national tobacco education campaign--March 19-June 10, 2012. *MMWR Morb Mortal Wkly Rep* 2012;61:667–70.
10 Xu X, Alexander RL, Simpson SA, *et al*. A cost-effectiveness analysis of the first federally funded antismoking campaign. *Am J Prev Med* 2015;48:318–25.
11 Congressional Budget Office. *Raising the excise tax on cigarettes: effects on health and the federal budget*. Washington: Congressional Budget Office, 2012.
12 Centers for Disease Control and Prevention. Best Practices for Comprehensive Tobacco Control Programs - 2014. In: *U.S. department of health and human services CfDCaP, National center for chronic disease prevention and health promotion, office of smoking and health*, 2014.
13 McAfee T, Davis KC, Alexander RL, *et al*. Effect of the first federally funded us antismoking national media campaign. *Lancet* 2013;382:2003–11.
14 TreeAge Pro Build-Id: 14.2.2.0-v20140820: (c) Copyright 1988-2014 TreeAge Software, Inc All rights reserved.; Version . 2014.
15 King M, Ruggles S, Alexander JT. Integrated public use Microdata series. current population survey, 2019. Available: https://cps.ipums.org/cps/
16 U.S. Census Bureau. Survey of income and program participation. Available: http://www.census.gov/programs-surveys/sipp/ [Accessed 18 Sep 2018].
17 National Center for Health Statistics. NHIS - Adult Tobacco Use Information. Smoking Status Recodes, 2019. Available: http://www.cdc.gov/nchs/nhis/tobacco/tobacco_recodes.htm [Accessed 27 Feb 2014].
18 Centers for Disease Control and Prevention,, National Center for Health Statistics. National health interview survey. Available: https://www.cdc.gov/nchs/nhis/ [Accessed 24 Feb 2017].
19 *The Health Benefits of Smoking Cessation. Rockville, MD: U.S. department of health and human services public health service centers for disease control center for chronic disease prevention and health promotion office on smoking and health*, 1990No. DHHS Publication No. (CDC) 90-8416.
20 Wetter DW, Cofta-Gunn L, Fouladi RT, *et al*. Late relapse/sustained abstinence among former smokers: a longitudinal study. *Prev Med* 2004;39:1156–63.
21 Herd N, Borland R, Hyland A. Predictors of smoking relapse by duration of abstinence: findings from the International tobacco control (ITC) four country survey. *Addiction* 2009;104:2088–99.
22 Hughes JR, Peters EN, Naud S. Relapse to smoking after 1 year of abstinence: a meta-analysis. *Addict Behav* 2008;33:1516–20.
23 Gilpin EA, Pierce JP, Farkas AJ. Duration of smoking abstinence and success in quitting. *J Natl Cancer Inst* 1997;89:572–6.
24 National Center for Health Statistics. *National Hospital Discharge Survey, 2010*. Hyattsville, Maryland: Public Health Service, 2010.
25 CDC Wonder. Compressed Mortality File - Underlying cause-of-deat. Available: http://wonder.cdc.gov/cmf-icd10.html [Accessed 02 May 2011].
26 Levy DE, Newhouse JP. Assessing the effects of tobacco policy changes on smoking-related health expenditures. In: Bearman PS NK, Wright L, eds. *After Tobacco: What Would Happen If Americans Stopped Smoking*. New York: Columbia University Press, 2011: 256–89.
27 Hockenberry JM, Curry SJ, Fishman PA, *et al*. Healthcare costs around the time of smoking cessation. *Am J Prev Med* 2012;42:596–601.

28 Fishman PA, Khan ZM, Thompson EE, *et al*. Health care costs among smokers, former smokers, and never smokers in an HMO. *Health Serv Res* 2003;38:733–49.
29 Fishman PA, Thompson EE, Merikle E, *et al*. Changes in health care costs before and after smoking cessation. *Nicotine Tob Res* 2006;8:393–401.
30 Miller VP, Ernst C, Collin F. Smoking-attributable medical care costs in the USA. *Soc Sci Med* 1999;48:375–91.
31 Grosse SD, Krueger KV, Mvundura M. Economic productivity by age and sex: 2007 estimates for the United States. *Med Care* 2009;47:S94–103.
32 Bureau of Labor Statistics. Employment cost index for the wages and salaries of all civilian workers. Bureau of labor statistics. Available: ftp://ftp.bls.gov/pub/suppl/eci.echistrynaics.txt [Accessed 30 Oct 2013].
33 Mitchell RJ, Bates P. Measuring health-related productivity loss. *Popul Health Manag* 2011;14:93–8.
34 Assistant Secretary for Planning and Evaluation, Department of Health and Human Services. *Federal Financial Participation in State Assistance Expenditures; Federal Matching Shares for Medicaid, the Children's Health Insurance Program, and Aid to Needy Aged, Blind, or Disabled Persons for October 1, 2016 through September 30, 2017*. Washington, DC: Department of Health and Human Services, 2017.
35 Levy DT, Mabry PL, Graham AL, *et al*. Reaching healthy people 2010 by 2013: a *SimSmoke* simulation. *Am J Prev Med* 2010;38:S373–81.
36 Yang W, Zou Q, Tan E, *et al*. Future health and economic impact of comprehensive tobacco control in DOD: a Microsimulation approach. *Mil Med* 2018;183:e104–12.
37 McAlister A, Morrison TC, Hu S, *et al*. Media and community campaign effects on adult tobacco use in Texas. *J Health Commun* 2004;9:95–109.
38 McVey D, Stapleton J. Can anti-smoking television advertising affect smoking behaviour? controlled trial of the health education authority for England's anti-smoking TV campaign. *Tob Control* 2000;9:273–82.
39 Hyland A, Wakefield M, Higbee C, *et al*. Anti-Tobacco television advertising and indicators of smoking cessation in adults: a cohort study. *Health Educ Res* 2006;21:348–54.
40 Ronda G, Van Assema P, Candel M, *et al*. The Dutch Heart Health Community Intervention 'Hartslag Limburg': effects on smoking behaviour. *Eur J Public Health* 2004;14:191–3.
41 Wakefield MA, Spittal MJ, Yong H-H, *et al*. Effects of mass media campaign exposure intensity and durability on quit attempts in a population-based cohort study. *Health Educ Res* 2011;26:988–97.
42 Sly DF, Arheart K, Dietz N, *et al*. The outcome consequences of defunding the Minnesota youth tobacco-use prevention program. *Prev Med* 2005;41:503–10.
43 Dono J, Bowden J, Kim S, *et al*. Taking the pressure off the spring: the case of rebounding smoking rates when antitobacco campaigns ceased. *Tob Control* 2019;28:233–6.
44 Zhao X, Cai X. The association between exposure to "Tips" and smoking-related outcomes among adolescents in the United States. *Health Educ Res* 2016;31:614–23.
45 U.S. Department of Health and Human Services. *Youth and Tobacco—Preventing tobacco use among young people: a report of the surgeon general, 1994. 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*, 1994.
46 Centers for Disease Control and Prevention. Youth risk behavior survey (YRBS), 2011. Available: http://www.cdc.gov/healthyyouth/yrbs/index.htm [Accessed 27 Feb 2014].
47 Centers for Disease Control and Prevention (CDC). Quitting smoking among adults--United States, 2001-2010. *MMWR Morb Mortal Wkly Rep* 2011;60:1513–9.
48 Chowdhury SMS, Wun L. *Linking Medical Expenditure Panel Survey to the National Health Interview Survey: Weighting and Estimation. Working Paper No. 12005*. Rockville, MD: Agency for Healthcare Research and Quality, 2012.
49 Consumer Price Index-All Urban Consumers. U.S. Bureau of labor statistics, 2016. Available: http://data.bls.gov/cgi-bin/dsrv?cu [Accessed 20 Jul 2016].
50 Bureau of Labor Statistics. Consumer Price Index - All Urban Consumers, Medical care, 2015. Available: http://data.bls.gov/cgi-bin/srgate