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Authors

Sheridan, Paige
Trinidad, Dennis
McMenamin, Sara
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Short communication

Evaluating the impact of the California 1995 smoke-free workplace law on population smoking prevalence using a synthetic control method

Paige Sheridan[a,b,*], Dennis Trinidad[a], Sara McMenamin[a], John P. Pierce[a], Tarik Benmarhnia[a,c]

[a] Department of Family Medicine and Public Health, School of Medicine, University of California San Diego, 9500 Gilman Drive, La Jolla, CA 92093, United States
[b] Division of Epidemiology and Biostatistics, School of Public Health, San Diego State University, 5200 Campanile Drive, San Diego, CA 92182, United States
[c] Scripps Institute of Oceanography, University of California San Diego, 8622 Kennel Way, La Jolla, CA 92037, United States

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ABSTRACT

The objective of this study is to assess the impact of the California 1995 Smoke-Free Workplace Act (SFWA) on cigarette smoking prevalence in the population. We used survey responses related to cigarette smoking from the Behavioral Risk Factor Surveillance System (BRFSS) from 1990 to 2000. We utilize a synthetic control method which creates a weighted combination of control states to produce a single 'synthetic' control group to best approximate the counterfactual trend in California in the absence of the SFWA. Variables known to be associated with smoking were included to weight each state in the pre-intervention period as medians by state and included: distribution of race/ethnicity (White, Black, Asian, Hispanic), sex (Male/Female), marital status (married/unmarried), high school education (yes/no) and employment status (yes/no).

We find evidence that there was a small decrease in population smoking prevalence in California in the year immediately following the SFWA, but this effect was not sustained beyond 1995. We hypothesize that one potential explanation for the lack of prolonged impact on population smoking prevalence is that there are sustained effects from the passage of 1989 California Proposition 99, which enacted an excise tax on tobacco products. Understanding how workplace smoking ban legislation affects population smoking behaviors is necessary to better inform policy development in other states and counties and to improve existing policies. Future work should consider the impact of smoking legislation impacts subgroups of the population by socioeconomic status, occupation or race/ethnicity.

1. Background

There are significant health consequences associated with cigarette smoking and second-hand smoke (SHS) exposure including cancer, cardiovascular disease and respiratory conditions (Health effects of exposure to environmental tobacco smoke, 1997; Dunbar et al., 2013; Ma et al., 2014). Public awareness of the negative effects of smoking has led to legislatures working to control tobacco access and use across the world (Public, 2008). In 1989, California (CA) became the first state in the US to enact comprehensive smoking legislation, the Tobacco Tax and Health Protection Act (Proposition 99), which imposed a 25 cent per pack excise tax on the sale of cigarettes and other tobacco products in CA. Following Proposition 99, CA passed the first legislative workplace smoking ban in 1995, the Smoke-Free Workplace Act (SFWA) (CA Labor code Sec 6404.5). The primary goal of this legislation was to protect workers from SHS exposure (Kiser and Boschert, 2001). However, smoke free workplace policies may also motivate tobacco users to quit, prevent initiation of tobacco use, and reduce smoking prevalence among workers and the general population (Fichtenberg and Glantz, 2002). To date, only 27 other states in the US have passed comprehensive smoke free workplace laws. This means that while smoking and SHS remain a substantial public health burden, only 50% of the US is protected by smoke-free laws (Tynan et al., 2016).

The extent to which workplace smoking bans impact population smoking prevalence and smoking behaviors remains unknown. Results from previous studies (Fichtenberg and Glantz, 2002; Organization and Control, 2008; Longo et al., 1996; Chapman et al., 1999; Farrelly et al., 1999; Woodruff et al., 1993) suggest that in addition to reducing SHS exposure, workplace smoking bans are also associated with changes in smoking behaviors and smoking prevalence among employees.

*Abbreviations:*SFWA, Smoke-Free Workplace Act

* Corresponding author at: Department of Family Medicine and Public Health, University of California, San Diego, School of Medicine, 9500 Gilman Drive, La Jolla, CA 92093, United States.
E-mail address: psherida@ucsd.edu (P. Sheridan).

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However, there is less evidence for the impact of workplace smoking bans on populations outside of the workplace (Levy et al., 2004). It is plausible that workplace restrictions may help establish new norms around smoking and encourage education around the dangers of SHS (Biener et al., 2010). Further, workplace restrictions may stimulate subsequent adoption of home bans which may translate to benefits at the population level (Borland et al., 2006). Results from studies that have examined the impact of workplace smoking bans on population smoking prevalence and quitting behaviors beyond workplace employees have been inconsistent (Frazer et al., 2016). One study in the Netherlands found decreases in smoking prevalence after the enactment of smoke-free workplace laws (Nagelhout et al., 2011), while others found no declines in smoking prevalence (Elton and Campbell, 2008; Edwards et al., 2008). To the best of our knowledge, there are currently no studies that estimate the impacts of CA's 1995 SFWA on population smoking prevalence. It is necessary to understand how workplace smoking bans affect widespread smoking prevalence to inform targeted policy development to reduce morbidity and mortality associated with cigarette smoking and SHS. In this study, we use a synthetic control approach to examine the impact of the 1995 SFWA on current smoking prevalence in CA.

2. Methods

We use a synthetic control method (SCM) in this analysis, which has been used previously for estimating the effects of policy changes or interventions (Abadie et al., 2010; Abadie and Gardeazabal, 2003; Bouttell et al., 2018; Gobillon and Magnac, 2015; Goin et al., 2017). The SCM was proposed as a method to evaluate the impact of a treatment on a single unit in settings with a small number of control units (Abadie et al., 2010; Abadie and Gardeazabal, 2003). In this method, we compare the outcome of interest over time between the treated unit (California) and a weighted combination of the control units (states with no widespread smoking policies in place), called the 'synthetic control'. The rationale behind this approach is that a weighted control group may better approximate the counterfactual scenario for the treated unit than one single control.

In this study, we are using the synthetic control to approximate the counterfactual trend in smoking prevalence in CA in the absence of the 1995 SFWA. The synthetic control is created by weighting all available control states based on their lagged outcomes (smoking prevalence) and selected covariates from 1990 to 1995 (the pre-intervention period) to best approximate the smoking prevalence in California during this same time period. The set of covariates and lagged outcomes that yields the smallest mean squared prediction error (MSPE) in the pre-intervention period are then used to create the weighted synthetic control group for analysis. A small MSPE in the pre-intervention period ensures that the pre-intervention trends are well matched between the exposed and control groups. If there is a close match in the pre-intervention period, the difference between the observed and expected prevalence from the synthetic control in the post-intervention period can be interpreted as the impact of the 1995 SFWA.

We used data from the Behavioral Risk Factor Surveillance System (BRFSS) from 1990 to 2000. Only survey respondents over the age of 18 were included. Because many states enacted several tobacco control laws after the year 2000, the last post-intervention year used for this analysis was 2000. States that enacted major laws between 1990 and 2000 were excluded: Alaska, Arizona, Florida, Hawaii, Maryland, Massachusetts, Michigan, New Jersey, New York, Oregon, Washington. The final study dataset included California and 38 control states. Our outcome of interest in this study was the prevalence of current smokers in the study population. We included a lagged value for this outcome for each year in the pre-intervention period (1990–1995). Variables known to be associated with smoking were included to weight each state in the pre-intervention period as medians by state and included: distribution of race/ethnicity (White, Black, Asian, Hispanic), sex (Male/Female), marital status (married/unmarried), high school education (yes/no) and employment status (yes/no). We intended to additionally include quit attempts among current smokers as a secondary outcome. However, the match between California and the synthetic control for this outcome was poor, which would not allow us to make any inference about the impact of the policy quit attempts. For this reason, this outcome was excluded from further analysis. The graphical results for the synthetic control for quit attempts are presented in Supplementary Fig. 1.

Because of the nonparametric nature of this method, traditional statistical inference techniques do not apply (Firpo and Possebom, 2018; Hahn and Shi, 2017). Therefore, to estimate how unusual the effect we found would be if it were due to chance alone, we apply a permutation test (Goin et al., 2017). The permutation test creates a synthetic control group for each state, had it experienced a 1995 policy. The estimated effect we find for CA can then be compared to the effect size for all other states that did not enact such a policy. We present the results of the permutation test for states within two times the pre-intervention MSPE observed for CA, to ensure that we are comparing effects to well matched synthetic controls only.

3. Dataset validation

As the BRFSS dataset has not previously been used in this context, we validated the use of these data by replicating previous work by Abadie et al. (2010) in estimating the effect of 1989 Proposition 99 in CA on per capita cigarette sales using the synthetic control approach. We use our current smoking outcome in place of cigarette sales, and the same covariates as described above from 1984 to 2000. In addition to California, only 11 states collected complete data during this time and were included: Idaho, Illinois, Indiana, Minnesota, Montana, North Carolina, Ohio, South Carolina, Utah, West Virginia, and Wisconsin.

4. Results

Current smoking in California declined over the study period from around 20% in 1990 to 16% in 2000. The synthetic control appears to well approximate the pre-intervention prevalence for current smoking. The true prevalence of current smoking in California is below the synthetic control from 1995 to 1998, increasing to the prevalence of the synthetic control in 1998 (Fig. 1). In our replication of the work by Abadie et al. we find that smoking prevalence decreased in California after the passage of Proposition 99 with sustained effects through 2000 (Fig. 1).

The covariates and weights for the smoking prevalence synthetic control are listed in Supplementary Table 1. The states and their weights included in the synthetic control are shown in Supplementary Table 2. Results from the permutation test indicate that these differences between the observed and expected prevalence may have only been significant in the year immediately following the 1995 SFWA but are not sustained through the study period (Fig. 2). In the replication of Abadie et al. results from the permutation test suggest that the observed effect is different from that of other states. This indicates a difference in observed and expected smoking prevalence and demonstrates a sustained effect of Proposition 99 on smoking prevalence in California (Fig. 2). These results are consistent with the original work which demonstrated a decrease in per capita cigarette sales following Proposition 99.

5. Discussion

We find evidence that there was a brief decrease in population smoking prevalence in the year immediately following the passage of the 1995 SFWA. However, we do not find evidence that there was a sustained effect on smoking prevalence beyond this time. There are several potential explanations for the lack of sustained effect of the

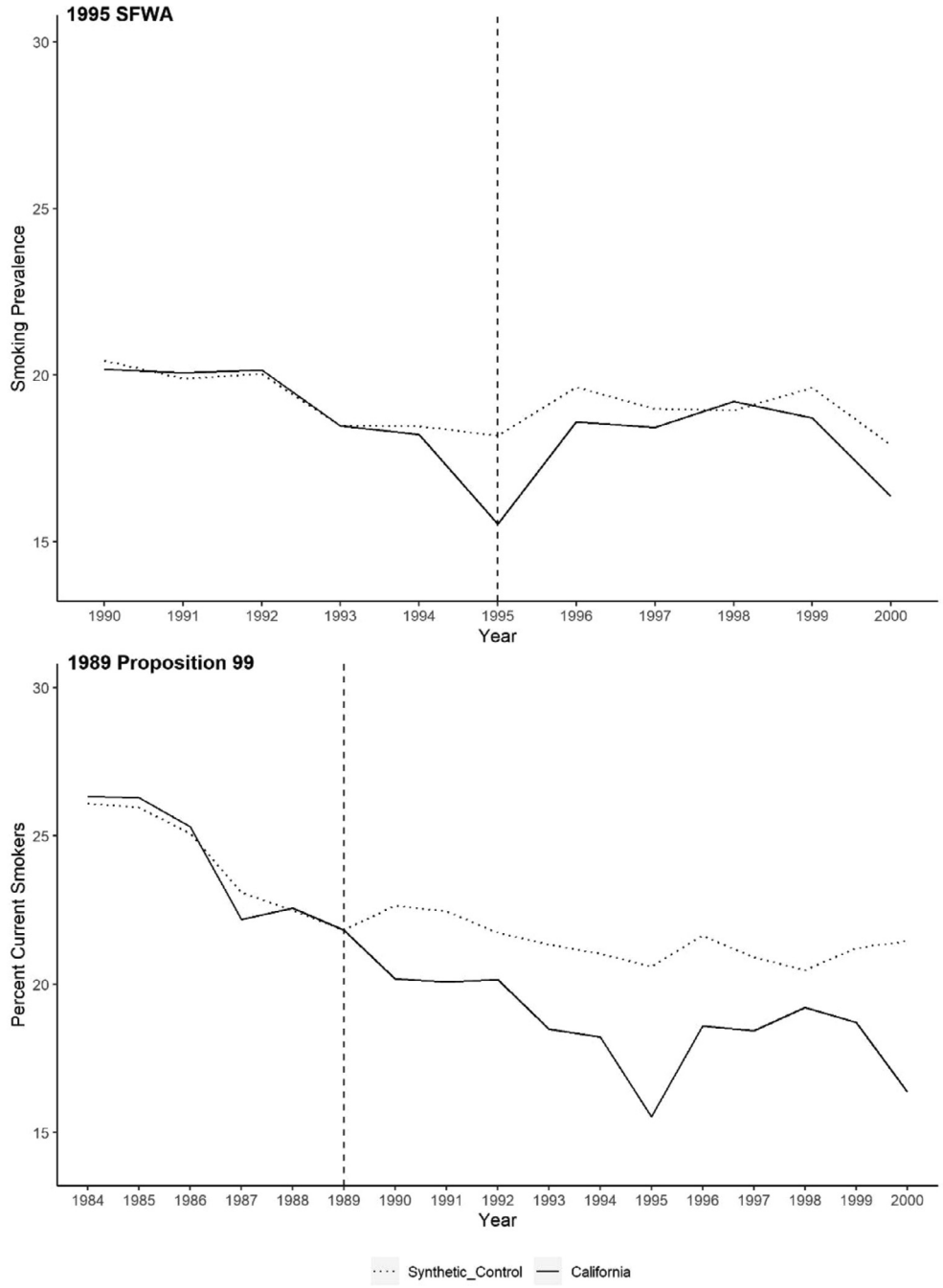

Fig. 1. Current smoking prevalence in California and synthetic control prevalence after the 1995 Smoke-Free Workplace Act and the 1989 Proposition 99 smoking legislation.

1995 SFWA on population smoking prevalence. We hypothesize that there are continued effects from the passage of Proposition 99 in 1989, limiting direct effects from the SFWA in 1995. This is supported by our replication of Abadie et al. where we find evidence that Proposition 99 was associated with decreased smoking prevalence in California up to 2000. Further, media coverage regarding the harmfulness of second-hand smoke started in 1981 in CA (Pierce and Gilpin, 2001) and may also had an early indirect impact on the workplace. Finally, it has been shown that in CA, city and county level ordinances were incrementally implemented before the passage of this law, potentially limiting the size of the effect in 1995 (Pierce et al., 1994).

Our findings support previous systematic reviews that show that workplace smoking bans may decrease exposure to SHS, but do not substantially reduce smoking prevalence in the population (Frazer et al., 2016; Callinan et al., 2010). The lack of a strong association between workplace smoking bans and changes in smoking prevalence may reflect the challenge in implementing robust workplace bans (Levy et al., 2004). It is important to understand the limitations of these workplace bans and to identify what legislation is needed to decrease smoking prevalence in the population.

There are several limitations in this study that should be considered. First, there was likely differential implementation of the law over time, resulting in a potential violation of the common shock assumption (Abadie et al., 2010) and some exposure misclassification assuming implementation was uniform across CA. The 1995 SFWA law allowed for wide flexibility in implementation and enforcement of the law, usually determined by city councils or board of supervisors. Second, enactment of the ordinance was delayed for bars and restaurants until

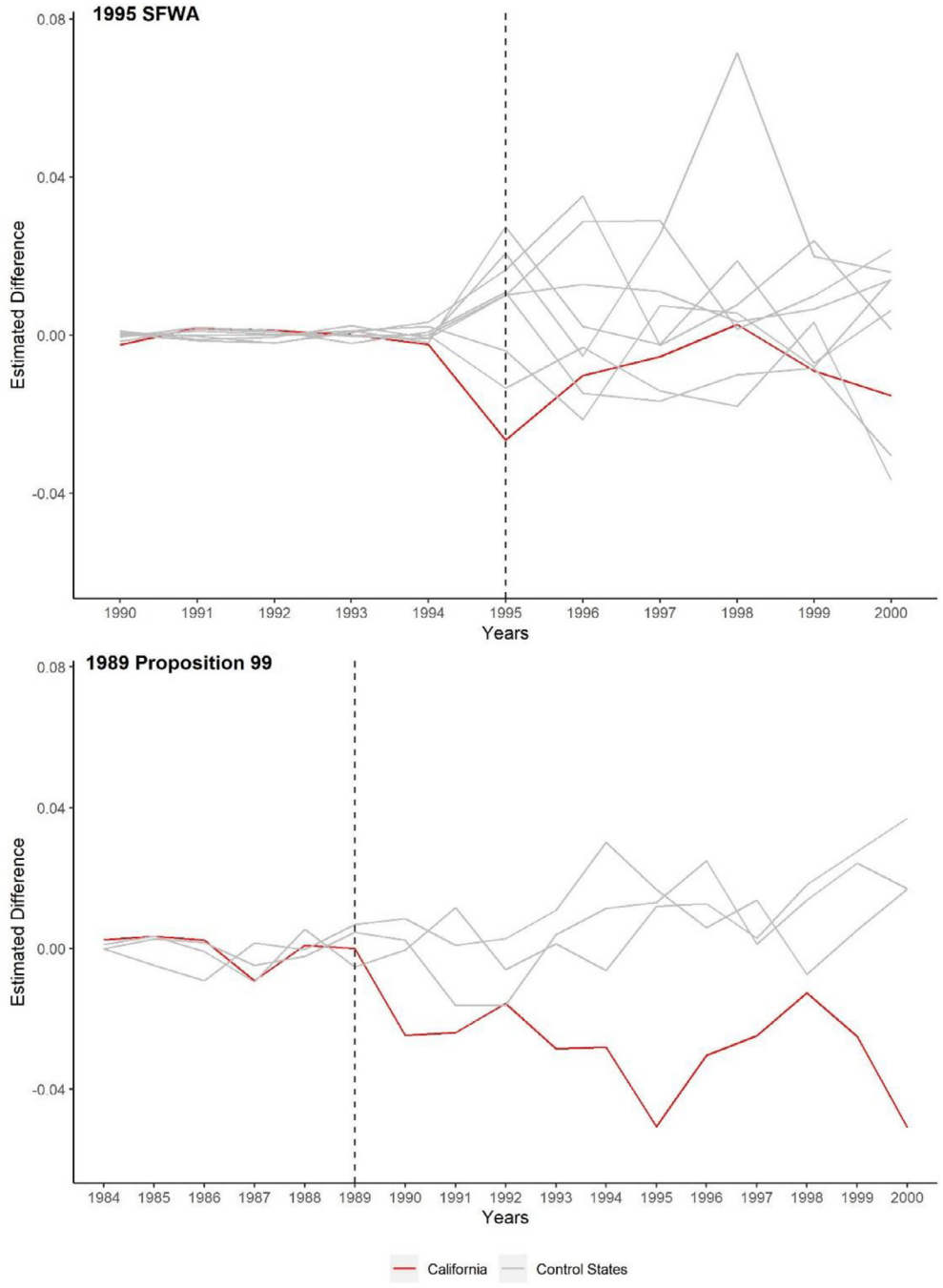

Fig. 2. Permutation Test with California and Control States for the 1995 Smoke-Free Workplace Act and the 1989 Proposition 99 smoking legislation.

1998, resulting in varying implementation from 1995 to 1998. Third, the present study was unable to capture differences in the effect of the law at the county or city level, which may be important when considering populations targeted by such legislation. Finally, we were unable to assess smoking cessation as an outcome due to large differences in pre-intervention trends after weighting. This may be an important outcome to assess and should be explored using alternative datasets. The SCM assumes that the passage of the SFWA in California did not affect smoking behaviors in other states that were included in our synthetic control group. If this was the case, we could assume that our estimated effect would be conservative. Similarly, our results would be attenuated if states that were included in this analysis enacted smoking ordinances that were not captured.

As smoking norms change, it is important to understand how smoking ban legislation affects population smoking behaviors to better inform policy development in other states and counties and to improve existing policies. While significant progress has been made in the adoption of comprehensive smoking legislation over the past several decades, recently this progress has stalled. Currently, some states without comprehensive smoke-free laws legally prohibit communities from adopting these policies to protect people from SHS exposure (Holmes et al., 2016). Gaps in these smoke-free laws fail to protect vulnerable populations from SHS, which may contribute to health disparities (Huang et al., 2015). Future work should explore how smoking ban legislation in California affects subgroups of the population by socioeconomic status, occupation status, or race/ethnicity.

CRediT authorship contribution statement

Conceptualization, Methodology, Project administration, Supervision, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2020.101164.

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