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Journal

Tobacco Control, 27(e2)

ISSN

0964-4563

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Publication Date

2018-10-01

DOI

10.1136/tobaccocontrol-2017-053895

Peer reviewed

Tobacco control in California compared with the rest of the USA: trends in adult per capita cigarette consumption

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Received 9 June 2017

Revised 8 November 2017

Accepted 14 November 2017

ABSTRACT

Background In the 1990s, California led the USA in state-level tobacco control strategies. However, after 2000, California lost ground on cigarette taxes, although it maintained higher levels of smoke-free homes among smokers.

Methods Trends in per capita cigarette consumption were assessed through taxed sales data and from self-report in repeated national cross-sectional surveys. Linear regressions identified changes in trends after year 2000 separately for California and the rest of the USA. Using data from each state, a linear regression tested the association between different tobacco control strategies and per capita consumption. Change in self-reported per capita consumption was partitioned into contributions associated with initiation, quitting and reduction in cigarette consumption level.

Results Both taxed cigarette sales and per capita consumption declined rapidly in the USA from 1985 to 2015. Declines were particularly fast in California before 2000 but slowed thereafter. In 2014, per capita consumption in California was 29.4 packs/adult/year, but 90% higher in the rest of the USA. Modelling state-level data, every \$1 increase in cigarette taxes reduced consumption by 4.8 (95% CI 2.9 to 6.8) packs/adult/year. Every 5% increase in the proportion of smokers with smoke-free homes reduced consumption by 8.0 (95% CI 7.0 to 8.9) packs/adult/year. The different patterns in California and the rest of the USA are at least partially explained by these two variables. The slow down in per capita consumption in California can be attributed to changes in initiation, quitting and especially smokers reducing their consumption level.

Conclusions Tobacco control strategies need to be continually updated to maintain momentum towards a smoke-free society.

INTRODUCTION

From the mid-1960s, California was an early adopter of tobacco control strategies and, as a result, experienced a greater declining trend in per capita cigarette consumption than the rest of the USA.¹ In 1988, California increased cigarette taxes to fund the first comprehensive tobacco control programme (TCP) in the USA, an innovative programme focused on disrupting the social norms that supported cigarette smoking and increasing protections against second-hand smoke exposure.^{2,3} This programme was associated with a

further doubling of the difference in trends in per capita consumption compared with the rest of the USA.¹ However, between 2000 and 2015, a series of University of California, San Francisco reports documented that California lost its leadership in tobacco control.⁴⁻⁷ During this period, two voter initiatives failed to increase cigarette taxes,⁸ and California's annual per capita expenditures for tobacco control equilibrated to the average across US states. Nevertheless, the prevalence of smoke-free homes in the nation remained highest in California.^{9,10} Home smoking rules are an indication of the strength of the social norms against smoking in a community, and they have been associated with reduced smoking behaviour.^{11,12} In this paper, we address the potential impact of California's relative downturn in policy implementation on this state's lead in lowering cigarette consumption.

As there are state taxes on cigarette sales in the USA, one measure of per capita cigarette consumption is through taxed sales receipts. However, high taxes may incentivise smokers to purchase their cigarettes from nearby jurisdictions with lower taxes, or cigarettes that have been smuggled into the state without payment of taxes.¹³ Analyses of California data have shown little evidence of tax evasion, probably because of preferential geolocation.^{14,15} While some states (eg, New York) have experienced significant tax evasion since 2000,¹⁶ the major source of substitute cigarettes is from within the USA. Thus, the comparison of trends in per capita taxed sales between California and the rest of the USA should reflect real cigarette consumption.

Nationally representative surveys offer another estimate of trends in per capita consumption. Self-reported smoking prevalence from population surveys has been biochemically validated,¹⁷ although there is significant digit preference in reporting the number of cigarettes/day consumed, suggesting that respondents may estimate their smoking in fractions of a pack (their purchase quantity), rather than from individual cigarettes smoked.¹⁸ The tendency for smokers to round down to the nearest quarter or half pack is one possible explanation why self-reported per capita consumption consistently underestimates taxed sales by as much as 35%–40% since before the start of TCP.^{19,20}

An advantage of using nationally representative surveys is the ability to partition changes in per capita consumption within each of the following



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To cite: Pierce JP, Shi Y, Hendrickson EM, *et al.* *Tob Control* Published Online First: [please include Day Month Year]. doi:10.1136/tobaccocontrol-2017-053895

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three components¹⁹: (1) the percentage of the population who are ever smokers, (2) the fraction of ever smokers who have quit and (3) the changing number of cigarettes consumed/day among continuing smokers. Many tobacco control interventions target changes in only one of these components (eg, interventions targeting teens or promoting cessation). Each component may have a different impact on longer term trends in per capita consumption. For example, reducing smoking initiation, which usually occurs before age 24 years, would have long-term impact while increasing quitting would have more immediate measurable impact given the larger number of adult smokers consuming cigarettes. During the 1990s, there was evidence that the California Tobacco Control Program reduced smoking initiation substantially.^{21,22} However, across the USA, quitting rates appear to have been quite stable for much of the past two decades,²³ although they may have increased in 2014.²⁴ Finally, since the mid-1960s, the prevalence of heavy smoking (>20 cigarettes/day) has dropped, with California declining at a faster rate than the rest of the USA,²⁵ and this will have a big impact on per capita consumption.

In this paper, we examine the trends in per capita consumption for California and the rest of the USA, testing whether these trends changed around 2000. We report patterns of change in both taxed sales data as well as self-reported consumption from two national surveys and calculate the relationship between these estimates. Using state-level data, we examine the relationship between the implementation of tobacco control strategies and per capita consumption. Finally, we identify how each of the three components of per capita consumption (initiation, quitting and smoking intensity) contributed to overall consumption within both California and the rest of the USA.

METHODS

Data sources

Data on taxed cigarette sales were obtained from ‘The Tax Burden on Tobacco’,²⁶ which includes details on per capita cigarette sales at the state level. To obtain an estimate for the rest of the USA as a group, we weighted state-specific sales (excluding California) by population size in each year.

For self-reported consumption, we used two national household surveys: The Tobacco Use Supplements to the Current Population Survey (TUS-CPS) and the National Health Interview Surveys (NHIS).

Tobacco Use Supplements to the Current Population Survey

We used eight TUS-CPS waves conducted between the years 1992 and 2015. In these surveys, using a complex probability survey design,²⁷ interviewers visit identified households representative of the non-institutionalised, civilian US population at the state and national level. Each TUS ‘wave’ included respondents from three separate months across a 9-month period of time (eg, 2014–2015).²⁷ Interviews were completed either in person (36%) or by phone according to the CPS panel design protocol. We limited our analysis to self-respondents (80% of sample), yielding an average self-response rate over the entire 13-year period of >60%. The typical annual sample size per ‘wave’ for California is >13 000 and for the rest of the USA is >175 000.

National Health Interview Surveys

The NHIS provides a representative estimate (for four US regions and a national estimate) of smoking behaviour from 26 surveys between 1985 and 2015. State identifiers were available to us

prior to 1995 and used in previous research.¹ For the later years, we obtained a data use agreement and statistical assistance from the National Center for Health Statistics (NCHS). Data were collated over 3-year period (eg, 2013–2015) for both California and the rest of the USA to ensure that the all subcells in the table met the NCHS minimum sample size to protect confidentiality. The NHIS annual household sample sizes range from 35 000 to 45 000 and have reported individual level response rates >60% for the period 1985 to early 1990s and comparable with the TUS-CPS thereafter.²⁸ The California population is ~10% of the national sample.

The TUS-CPS and NHIS each use the same standard questions to assess current and former smoking status and current cigarette consumption. Ever smoking is defined as lifetime smoking of at least 100 cigarettes. Current and former smokers were identified through a follow-up question: starting in 1992, this was: ‘Do you now smoke cigarettes every day, some days or not at all?’, and pre-1992, the question was simply: ‘Do you smoke cigarettes now?’ Daily smokers reported the number of cigarettes they smoked each day, and non-daily smokers reported the number of days they had smoked in the previous 30 days and the average number of cigarettes smoked on smoking days. For self-reported consumption from both TUS-CPS and NHIS, we computed the annual per capita cigarette consumption (packs/adult/year) as the weighted mean of 365*average number of cigarettes consumed per day* (non-smokers were assigned 0 consumption)/20.

STATISTICAL ANALYSES

For both taxed sales data and self-reported survey data, we modelled per capita consumption for California and the rest of the USA using a spline regression. We included a knot at the year 2000, which was close to the midpoint of the time period and coincided with the period when California’s tobacco control policy was labelled as stalled and adrift.⁴ We estimated the difference in slopes in each location before and after that time point. If there was no significant difference in slope, we reran the linear regression without the knot to provide a single estimate of the rate of change over the whole time period. Replicate weights were applied to TUS-CPS estimates,²⁹ and for NHIS estimates, we applied sampling design variables and weights. We standardised consumption estimates to the 2000 US census by age (18–34, 35–64 and 65+ years), gender and education (no college and some college). For the per capita taxed sales data, we plotted the difference in the annual estimates between California and the rest of the USA over the 1985–2014 period.

For each survey estimate (either NHIS or TUS-CPS), we fitted a linear model to identify the relationship between the annual per capita consumption estimates with corresponding estimates from taxed sales. Then, using the seven TUS-CPS years (1992–2011) for which we had all measures, we used linear regression with individual state-level data (50 states+DC) to assess the association between self-reported per capita cigarette consumption and the following tobacco control strategies for which we have reasonable measures: cigarette taxes (US\$), tobacco control expenditure per capita (includes media campaigns, quitlines, community organisation and so on),³⁰ and state variables derived from self-reported smoke-free workplaces (which include policies regardless of where they come from, such as local regulations, state policies or employer policies) and smoke-free homes. In a sensitivity analysis, we repeated the analysis with log-transformed cigarette consumption data.

Finally, using both TUS-CPS and NHIS data, we partitioned annual change in self-reported cigarette consumption (packs

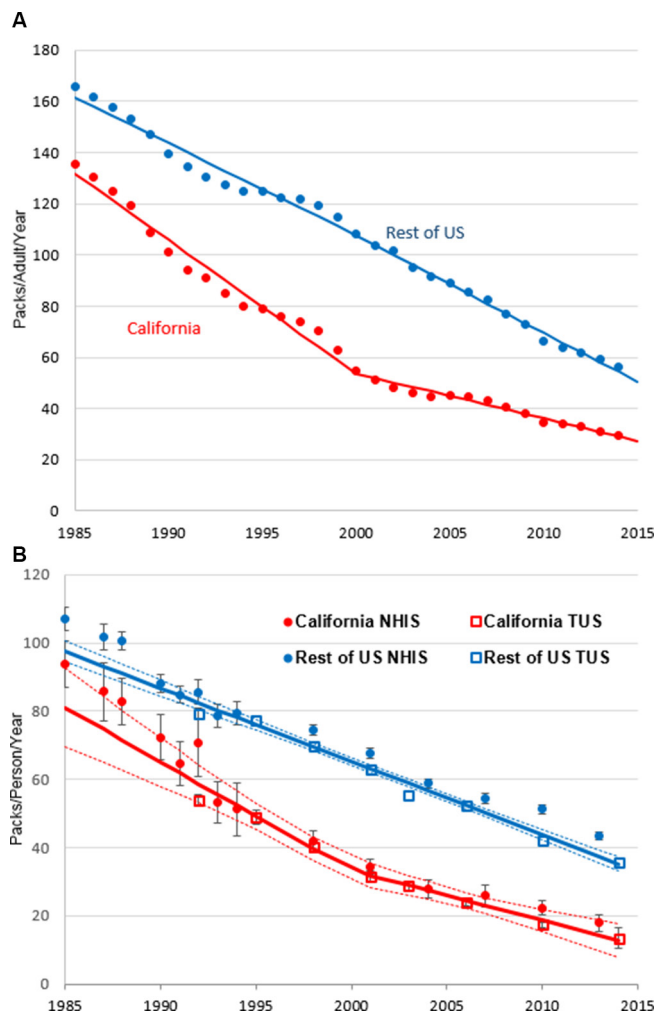


Figure 1 (A) Trends in per capita taxed sales in California and the rest of the USA: 1985–2014. Source: Tax Burden on Tobacco.²⁶ (B) Trends in self-reported per capita consumption in California and the rest of the USA (packs/adult/year). Source: NHIS, National Health Interview Surveys; TUS, Tobacco Use Supplements.

per person) in relation to three population components underlying cigarette consumption: proportion of ever smokers (E), proportion of former smokers (Q) and smoking intensity among current smokers (C). Period 1985–2000 and period 2000–2014 were estimated separately. Applying methods described in Gilpin *et al*,¹⁹ the decomposition was computed as:

$$\Delta(\text{PACKS}/P) = \Delta E * (1 - Q) * C + E * (-\Delta Q) * C + E * (1 - Q) * \Delta C$$

where $\Delta(\text{PACKS}/P)$ represents change in packs/adult/year, $\Delta E * (1 - Q) * C$ represents change in ever smokers (ie, initiation), $E * (-\Delta Q) * C$ represents change in former smokers (ie, quitting) and $E * (1 - Q) * \Delta C$ represents change in packs/year/person among current smokers (ie, current smoking intensity).

RESULTS

Trends in adult per capita cigarette consumption

The spline regression line provided a good fit to the taxed sales per capita data for both California and the rest of the USA for the period 1985–2015 ($R^2=0.99$) (figure 1A). Between 1985 and 2014–2015, there was no significant change in slope for

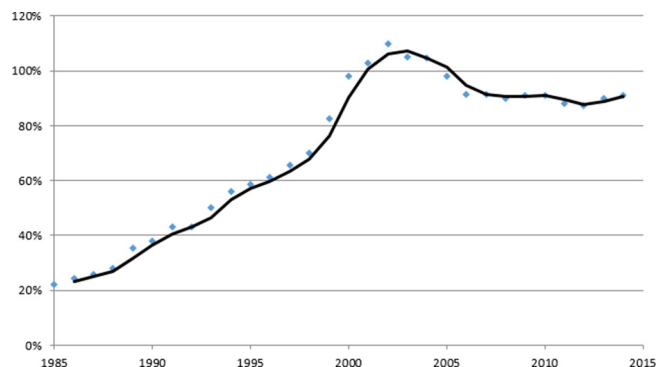


Figure 2 Per cent difference in per capita taxed sales between the rest of the USA and California compared with California sales: 1985–2014. Source: Tax Burden on Tobacco.²⁶ Percentage by which US taxed sales were higher than California sales ((US–CA)/CA). Individual trends are presented in figure 1A. The individual points represent 2-year moving averages.

the rest of the USA (-3.6 , $SE=0.14$ packs/year). For California, from 1985 to 2000, taxed sales declined by 5.2 ($SE=0.14$) packs/year, before slowing considerably to 1.74 ($SE=0.27$) packs/year from 2000 to 2014 ($P<0.01$). Taxed sales in California declined from 135.6 packs/adult/year in 1985 to 54.7 in 2000 (a reduction of 80.9 packs/adult) and then to 29.4 in 2014 (a further reduction of 25.3 packs/adult). For the rest of the USA, taxed sales declined from 165.7 packs/adult/year in 1985 to 108.3 in 2000 (a reduction of 57.4 packs/adult) and then to 56.1 in 2014 (a further reduction of 52.2 packs/adult). While both locations had a reduction of over 100 packs/adult over this time period, per capita consumption in California was 18% lower than the rest of the USA in 1985 and 48% lower in 2014.

The spline regression model of self-reported per capita consumption, including data points from both TUS-CPS and NHIS, was also a good fit to the data ($R^2_{\text{adj}}=0.98$) and provided a similar pattern of change over time (figure 1B). Again, there was no change in the annual rate of decline in per capita consumption in the rest of the USA. In California, the decline was significantly more rapid between 1985 and 2000 than after 2000 ($P=0.01$).

Using the taxed sales data, in 1985, taxed sales per capita were 22% higher in the rest of the USA compared with California (figure 2). With the introduction of the California cigarette tax in 1988, the gap increased to 28% and continued to increase with the conduct of the California TCP so that, at the end of the first decade (1998), per capita consumption in the rest of the USA was 70% higher than in California. In the next 5 years (1998–2002), the gap widened much more rapidly and, in 2002, the difference in per capita consumption in the rest of the USA peaked at 110% higher than in California. However, from 2003 to 2006, the gap narrowed (to 91%) and then stabilised through 2014.

Taxes sales versus self-reported consumption

A linear equation indicated that per capita taxed sales were 1.42 times self-reported consumption with the addition of an intercept of 10.9 packs/adult/year ($R^2=0.97$) (figure 3).

Associations between self-reported cigarette consumption and tobacco control policies

Table 1 presents the multivariable linear regression model for the state-level associations between self-reported per capita

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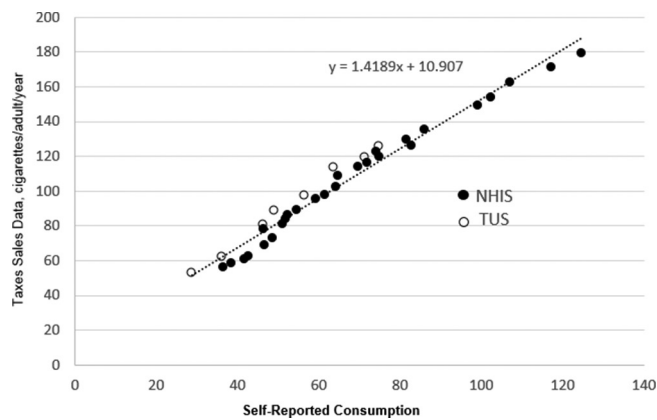


Figure 3 Association between per capita taxed sales of cigarettes and self-reported consumption from national surveys, 1980–2015 (packs/adult/year). Source: Tax Burden on Tobacco,²⁶ NHIS, TUS-CPS. NHIS, National Health Interview Surveys; TUS-CPS, Tobacco Use Supplements to the Current Population Survey.

cigarette consumption (packs/adult/year) and tobacco control policies ($R_{adj}^2=0.81$). For every dollar tax increase, cigarette consumption decreased by 4.8 cigarette packs per adult per year (95% CI 2.9 to 6.8; $P<0.0001$). The proportion of smokers with a smoke-free home also was associated with the level of cigarette consumption: every 5% increase in smokers with smoke-free homes was associated with a reduction in 8.0 (95% CI 7.0 to 8.9) cigarette packs consumed per year. Per capita tobacco control expenditure ($P=0.46$) and smoke-free workplace ($P=0.13$) were not significantly associated with cigarette consumption in this model. A sensitivity analysis using log-transformed cigarette consumption data produced similar results.

Partitioning changes in per capita consumption over the two periods

In table 2, we partitioned the decline in self-reported per capita consumption into change associated with initiation, quitting and consumption/smoker for each location for each time period. For the rest of the USA, from 1985 to 2000, estimated per capita consumption declined by 34 packs/adult. This represented 14.8 packs/adult (43%) from reduced initiation, 3.4 packs/adult (10%) from increased cessation and 16.1 packs/adult (47%) from reduced smoking intensity. For this period in California, estimated per capita consumption declined by 49 packs/adult, with 15.3 packs/adult (31%) from reduced initiation 9.9 packs/adult (20%) from increased cessation and 24.2 packs/adult (49%) from reduced smoking intensity.

Table 1 Associations of self-reported per capita cigarette consumption with tobacco control policies

Tobacco control policy	Parameter estimate (β)	95% CI	P value
Each \$ increase in tax rate per pack, \$2014	-4.82	-6.76 to 2.87	<0.0001
Per capita tobacco control expenditures, \$2014	0.11	-0.18 to 0.40	0.46
Proportion of workers reporting smoke-free workplace (%)	-0.13	-0.30 to 0.04	0.13
Each 5% increase in proportion of smokers reporting smoke-free home	-7.95	-8.93 to 6.97	<0.0001

Regression model included indicators for survey years and geographic region.

State-year observations=357, $R_{adj}^2=0.81$.

Source: 1992–2011 Tobacco Use Supplements to the Current Population Survey (seven surveys).

From 2000–2015, in the rest of the USA, estimated per capita consumption declined by 28 packs/adult. This represented 10.9 packs/adult (39%) from reduced initiation, 6.1 packs/adult (22%) from increased cessation and 11.2 packs/adult (40%) from reduced smoking intensity. For this period in California, estimated per capita consumption declined by only 19 packs/adult, with 8.5 packs/adult (45%) from reduced initiation, 4.5 packs/adult (24%) from increased cessation and 5.8 packs/adult (31%) from reduced smoking intensity.

DISCUSSION

Between 1988 and 2014, there was a marked consistent decline in cigarette consumption in the rest of the USA, whether measured by taxed sales or self-reported cigarette consumption from population surveys. This occurred largely because of a major decline in both smoking initiation and the intensity of smoking among continuing smokers with a much smaller contribution coming from smoking cessation. However, California did not have a consistent trend over this period, rather the decline was much faster for the period 1988–2000 after which it slowed considerably. Throughout the early period, the gap in per capita cigarette consumption between California and the rest of the USA increased consistently so that by 2000, the rest of the USA had more than double the per capita cigarette consumption of California. With the slowdown in California from 2000 to 2014, this gap stabilised so that per capita consumption in the rest of the USA was consistently around 90% higher than that of California. The major reason for the large increase and then slowdown in the decline in per capita consumption in California appeared to come from the marked change in contribution from smoking intensity among continuing smokers.

Using state-specific models with the self-reported per capita consumption data over this period, we confirmed the strong associations with per capita consumption of both state cigarette taxes³¹ and the proportion of smokers within a state who live in a smoke-free home.¹¹ While we were unable to confirm that state tobacco control expenditures were associated with changes in state per capita consumption, this finding may be an artefact of the considerable year-to-year volatility in this measure within all states, including California over the study period. Our population measure of the existence of smoke-free workplaces also was not significant in our model, although considerable evidence indicates that these laws effectively reduce consumption.^{32 33} The lack of significance in our model may reflect autocorrelation with the stronger smoke-free home variable.

Changes in state cigarette taxes may partially explain the marked change in the contribution to per capita cigarette consumption from smoking intensity of continuing smokers in California. Throughout the period from 1988 to 2000, California had significantly higher cigarette taxes than the average for the rest of the USA, mainly as a result of two large voter-initiated tax increases over the period.¹ However, Californian voters did not approve two initiatives to increase taxes between 2000 and 2014,⁸ whereas there were numerous increases in other states. Consequently, the California tax advantage was progressively eroded throughout the second period, and at the end of the period, California cigarette taxes were ranked in the bottom third of US states.²⁶ While these tax trends would lead us to expect a faster rate of decline in per capita consumption in California than the rest of the USA from 1988 to 2000 and a slower rate of decline from 2000 to 2014, they do not explain why the gap in per capita consumption between California and the rest

Table 2 Change in consumption partitioned into initiation, quitting and smoking intensity

Period	Region	Overall change in consumption (packs/adult/year)	Initiation (E)		Quitting (Q)		Smoking intensity (C)	
			ΔC	%	ΔC	%	ΔC	%
1985–2000	Rest of USA	(97–63)*=34	14.8	43	3.4	10	16.1	47
	CA	(81–32)*=49	15.3	31	9.9	20	24.2	49
2000–2015	Rest of USA	(63–35)†=28	10.9	39	6.1	22	11.2	40
	CA	(32–13)†=19	8.5	45	4.5	24	5.8	31

*1985 packs/adult/year–2000 packs/adult/year.

†2015 packs/adult/year–2000 packs/adult/year.

Source: TUS-CPS years (1992–2011).

of the USA stabilised in the second period. From the tax changes alone, this gap should have reduced.

The proportion of smoke-free homes among smokers in a state was also strongly associated with per capita consumption in our model. This variable is thought to reflect changes in the social and cultural norms related to smoking in the community³⁴ and likely directly impacts smoking intensity by placing barriers to key smoking situations such as after a meal or first cigarette in the morning.³⁵ Throughout the 1990s, the diffusion of smoke-free homes was particularly rapid among Californians⁹ where state mass media programmes emphasised the dangers of second-hand smoke in the house. More rapid diffusion in California compared with the rest of the USA from 1988 to 2000 would be expected to strengthen the effect of increased taxes on per capita consumption. A continued high number of smoke-free homes among smokers from 2000 to 2014 could help explain the stabilisation of the difference in per capita consumption between California and the rest of the USA, as this might counteract the effect of California's inability to raise taxes during this period. This potential impact of smoke-free homes needs further study.

A major strength of this study is the use of both an objective measure (taxed cigarette sales data) as well as estimates from two large nationally representative population surveys. As

California is the largest state in the nation, even though one of these national surveys (NHIS) does not usually report data at the state level, we were able to obtain data for our comparisons as none of the sample sizes were low enough to potentially jeopardise the confidentiality of the survey. The consistency of the estimates of per capita consumption across these two surveys, and the close correlation between changes in this variable from self-reported surveys and tax-based sales, enhances the validity of the findings. However, both biological and social trends in populations suggest that in any rate of change will slow prior to achieving an asymptote (that may be zero).³⁶ Accordingly, we undertook sensitivity analyses using log-transformed data to check whether change had departed from its previous linear relationship. These analyses did not alter our key findings. A limitation is that we did not have estimates of several influences on tobacco use behaviour, particularly tobacco marketing expenditures at the state level. Additionally, the large fluctuations in state tobacco control funding of antismoking media programmes and community organisational activities over the period of this study meant that we were unable to draw conclusions on how they may have impacted the differences in per capita consumption between the two locales.

CONCLUSIONS

Between 1988 and 2014, per capita cigarette consumption declined considerably across the USA. However, the rate of decline from 1988 to 2000 was much faster in California than in the rest of the USA. By 2000, per capita consumption in the rest of the USA was double what it was in California. From 2000 to 2014, the decline in per capita consumption in California slowed down, and the gap stabilised with the rest of the USA consistently consuming approximately 90% more than the 29.4 packs/adult/year consumed in California in 2014. California's slowdown after 2000 occurred in each of the three components of overall per capita consumption: initiation, quitting and particularly smokers' average daily cigarette consumption. The differential change in California appears to be at least partially explained by differences in cigarette tax increases and by smokers' implementing smoke-free homes, both of which are associated with comprehensive TCPs. It is important for states to maintain and revitalise tobacco control policies to maintain their momentum towards a smoke-free society.

Contributors JPP and YS conceptualised and designed the study. Under the supervision of KM, EMH and MW carried out analyses. All authors reviewed and revised the manuscript and approved the final manuscript as submitted.

Funding This study is supported with funds from the Tobacco-Related Disease Research Program (23RT-0016, 24RT-0036, and 24ST-0050).

What this paper adds

- ▶ Per capita cigarette consumption has been shown to decline with implementation of state-level tobacco control strategies.
- ▶ California was an early implementer of state-level tobacco control strategies but was unable to further increase cigarette taxes and lost leadership on implementation of tobacco control policies between 2000 and 2015.
- ▶ It is not known how California's slowdown in implementing tobacco control strategies after 2000 influenced per capita cigarette consumption.
- ▶ With the implementation of California's comprehensive tobacco control programme, per capita consumption quickly declined to about half that of the rest of the USA.
- ▶ After 2000, this momentum was lost, and the per capita consumption gap stabilised.
- ▶ The loss of effect occurred in each of the three components of per capita consumption: initiation, quitting and particularly in consumption level among continuing smokers.
- ▶ Both increased cigarette taxes and diffusion of smoke-free homes among smokers were major determinants of change in per capita consumption and help explain the changes in California compared with the rest of the USA.

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Disclaimer The study was reviewed and approved by the University of California, San Diego Human Research Protections Program. The views expressed here are those of the authors only and do not represent any official position of the National Cancer Institute or National Institutes of Health.

Competing interests None declared.

Ethics approval University of California, San Diego Human Research Protections Program.

Provenance and peer review Not commissioned; externally peer reviewed.

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Tob Control published online November 27, 2017

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