Evaluation of California's in-school tobacco use prevention education (TUPE) activities using a nested school-longitudinal design, 2003—2004 and 2005—2006

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ABSTRACT

Background Current legislative language requires the California Department of Public Health, California Tobacco Control Program, to evaluate the effectiveness of the school-based Tobacco Use Prevention Education (TUPE) programme in California every 2 years. The objective of the study was to measure change and to identify the impact of school-based tobacco use prevention education activities on youth smoking prevalence and attitudes over time, spanning two school year surveys (2003—2004 and 2005—2006).

Methods Evaluation focused on school-based tobacco use prevention activities in 57 schools (student sample size, n=16 833) that participated in the in-school administration of the 2003—2004 and 2005—2006 California Student Tobacco Surveys. Hierarchical linear models were used to predict student tobacco use and precursors to tobacco use.

Results Overall, student tobacco use, intention to smoke, number of friends smoking and perceived smoking prevalence by peers increased as students moved through grades 9 and 10 to grades 11 and 12. TUPE-related activities showed a suggestive association (p=0.06) with reduced rate in student tobacco use between the two surveys after adjusting for other contextual factors such as each school's socioeconomic characteristics.

Conclusions TUPE activities appears to be beneficial in reducing tobacco use in California high school students over time. Other contextual factors were important moderating influences on student tobacco use.

INTRODUCTION

Early smoking initiation increases the likelihood of adult smoking dependence.[1] Historically, studies showed that 80% of US adult smokers between the ages of 30 and 39 began to smoke during their adolescent years; in other words, few Americans appeared to initiate smoking after age 20.[2] [3] This suggests that if youth smoking can be prevented, fewer adults will be smokers.[2] However, more recent evidence suggests that reductions in youth initiation have been associated with increases in initiation among older adolescents and young adults.[4]

Many influences have been shown to increase the risk of smoking initiation. They include social environmental influences such as having a parent, sibling or close friend who smokes, perceiving peer smoking prevalence to be high or living in a home where smoking is allowed.[5] [6] Depression, low school grades and stressful life events may increase the risk of smoking initiation. Tobacco-specific experiences, such as the use of smokeless tobacco, perceived instrumental value of smoking and previous experimentation with tobacco, have also been shown to increase risk for initiation.[5—9] Two character traits predictive of smoking are risk-taking/rebelliousness and susceptibility to smoking.[9] [10] Finally, media influences (eg, anti-tobacco advertising, smoking in movies and news media coverage) have also been documented to be an important part of an adolescent's social and environmental context and have the potential to shape attitudes and behaviours.[11]

School-based tobacco-use prevention interventions have the capacity to integrate prevention information into school curricula and the advantage of reaching adolescents. In the short-term, school-based tobacco-use prevention interventions have been found to be considerably effective in reducing prevalence and initiation, and improving smoking intentions and attitudes.[12—16] Conversely, school-based interventions have been found to be generally ineffective in preventing long-term initiation.[17] However, these interventions have been found to be effective when combined with other approaches such as media campaigns and smoke-free policies.[18]

In November 1988, California voters approved the Tobacco Tax and Health Protection Act (Proposition 99), which added a $0.25 tax to each pack of cigarettes and a proportional amount to other tobacco products sold in the state. Since 1994, the California Department of Education has allocated school-based Tobacco Use Prevention Education (TUPE) programme funds from the tax to school districts. The legislative language of Proposition 99 requires that the California Department of Public Health, California Tobacco Control Program, evaluate the effectiveness of the school-based TUPE programmes in California every 2 years. However, an important evaluation challenge is that students may be exposed to other tobacco prevention education efforts as part of alcohol, tobacco and other drug programmes that are required under the federal Safe and Drug-Free Schools and Communities Act.

Since the early 1990s California s have had significantly lower smoking prevalence compared

to youths in the rest of the USA.[19] Moreover, California's low experimentation rates among adolescents appear to extend into young adulthood.[20] The objective of the current study was to measure changes and to identify the impact of school-based tobacco education activities on youth smoking prevalence and attitudes with two California in-school surveys of 9th through 12th graders in California conducted in the school years 2003—2004 and 2005—2006.

METHODS
Sampling
The study used a school-based multi-stage, stratified cluster sampling design. The sampling frame consisted of all public high schools in California, with exclusions for alternative or private schools and for school with less than 50 students enrolled in grades 9—12. At the first stage of sampling, 180 high schools were selected randomly proportional to size (enrolment) from 12 geographic strata, by similar geographic characteristics assigned by the researchers. In 2003—2004, 156 (86%) schools participated in the original survey to obtain a state-wide estimate on smoking prevalence.

For the current study, a second school sampling occurred. From among the 156 high schools, a random subsample of 65 schools was invited to participate again in 2005—2006. Of the 65 subsampled high schools that participated in the 2003—2004 survey, 57 schools agreed to participate in the 2005—2006 survey (87.7% school participation rate), with at least two schools participating in each region of the state.

At the second stage of sampling, one to two classes per grade were selected randomly each year from each participating school. All students within a selected class were eligible to participate, and a total of 16 833 students (76.3%) participated in the two surveys. The demographic and tobacco use characteristics of the participating and non-participating schools are given in appendix I. There were no differences in gender composition and lifetime tobacco use between the participating schools (n=57) and 'lost to follow-up' (n=8) schools. White students were present in lower numbers (43.6% vs 58.3%) and Hispanic students were more prevalent (37.6% vs 13.0%) in the participating schools.

Data sources
California Student Tobacco Survey (CSTS)
The CSTS is a 99-item multiple-choice instrument, with item content based largely on the questions found in the National Youth Tobacco Survey (NYTS-US) and the Independent Evaluation of Tobacco Use Prevention Education (TUPE) programme in California such as smoking behaviours, attitudes, knowledge and awareness about tobacco and tobacco use prevention. The survey was voluntary and anonymous.

Surveys for teachers, administrators and coordinators
The sampling frame for the teacher, school administrator and school TUPE coordinator surveys consisted of all schools/classrooms that administered the CSTS. Teachers in each classroom of surveyed students were asked to complete a 63-item questionnaire on attitudes towards school-based tobacco use prevention activities, tobacco use prevention programmes and policies at their school, and their own personal tobacco-related attitudes and behaviours. A school site administrator (eg, principal, assistant principal or vice principal) from each school was asked to complete a 39-item questionnaire regarding the administration of tobacco programmes at their school. A 67-item multiple-choice and free-response (blank spaces, one open-ended question and a section for comments) questionnaire was given to TUPE site coordinators or health teachers at each school site.

Only seven students (0.08%) did not have a value for the smoking index and they were omitted from the analysis. For all other summary measures, fewer that 3% of the respondents had missing values and those values were imputed as the grand mean.

Weighting
A weight was applied to each student record to adjust for varying probabilities of selection at each sampling stage, for variable student non-response and to correct for disproportionate population sampling. For the model-testing purposes of this study, weights were constructed such that each school and each grade within the school had an equal weight. The primary concern was the ability to generalise results to high schools in California in general and to examine relative differences between groups of high schools or between the two time points. An equal school-grade weighting scheme was appropriate for this type of model-testing.

The specific weight used for each student (i) was given by:

$$W_{igs} = 40 * N_{gs}^{-1}$$

N_{gs}^{-1} represents the inverse of the sample size in each grade (g) in each school (s). The value of 40 is the average N_{gs}. Similarly, adult survey data were weighted by the inverse of the number of adult respondents of each type (ie, one administrator, one TUPE coordinator and multiple teachers) at the school (ie, teachers responses were averaged). The student weights were scaled so that the sum of the weights was equal to the number of respondents, and the adult weights were scaled so that the sum of the adult weights was equal to the number of schools.

Birth cohorts
For the purpose of this study, students were grouped by birth year in order to measure any developmental continuum trends by age. Birth cohort trends are useful because they have expected rates of growth (as opposed to levels) over time that can be evaluated as a function of exposures to environmental factors such as educational programmes.

For instance, a high school monitored over a 2-year interval contains a student birth cohort of 9th and 10th graders most of whom become the school's 11th and 12th graders 2 years later. Students sampled from the birth cohort at each time point constitute the primary data for the analyses. Since all surveys were completed anonymously, it was not possible to follow individual students. However, we assumed that the sample of students at the same school would show the same development trajectory.

Analytical strategy
Linear mixed model variants, including the random coefficients model and the hierarchical linear model, were used for analysis.[21] The hierarchical linear model can be conceptualised as a two-stage system of equations in which the individual variation within each school is explained by a student-level equation (level-1), while the variation across schools in the school-specific regression coefficients is explained by a school-level equation (level-2).

In the first stage, a separate student-level regression is defined for each school (j). Here the units of analysis are individuals (i) and the specified regression models are of the following general form:

$$Outcome_{ij} = \beta_{0j} + \beta_{1j} * Year_{ij} + \beta_2 * Demographics_{ij} + e_{ij}$$
[1]

In this equation, the random coefficient, β_{1j} represents the change of the year variable for the birth cohorts on the outcome at each school (j). This refers to cohort trends in outcomes for 9th and 10th grade students in 2003–2004 as they move to grades 11 and 12 in the 2005–2006 school year.

In the second stage, each of the cohort trends (β_{1j}) is modelled as a function of school-level input, and activity variables (collectively labelled here as 'practices') and other external factors. In this second stage, the school is the unit of analysis and the specified regression models have the following general form:

$$\beta_{1j} = \gamma_{10} + \gamma_{11} * Practices_j... + \gamma_{12} * External\ Factors_j... + \mu_{1j}$$
[2]

$$\beta_{0j} = \gamma_{00} + \gamma_{01} Practices_j... + \gamma_{02} * External\ Factors_j... + \mu_{0j}$$
[3]

In these equations, γ_{10} represents the mean cohort trend in the outcome across schools and γ_{11} indexes the influence of practices on that trend. The influences of school-level and community-level external factors such as school size, or relative affluence, on that trend are captured by γ_{12}. Similarly, equation 3 coefficient γ_{00} represents the overall average of the Outcome at baseline, γ_{01} indexes the effect of variations in Practices, and γ_{02} indexes the average of the variations in External Factors at that baseline. Equations 1, 2, and 3 above are combined into a single equation for estimation purposes:

$$Outcome_{ij} = \gamma_{00} + \gamma_{10} Year_{ij} + \gamma_{01} Practices_j + \gamma_{11} Practices_j$$
$$* Year_{ij} + ... + \mu_{1j} X_{ij} + \mu_{0j} + e_{ij}$$
[4]

Of particular interest in the combined equation are: the coefficient on $\gamma_{10} Year_{ij}$, which again specifies the change in the outcome over time; the coefficient γ_{01} on Practice$_j$, which specifies the cross-sectional effects of Practice on the outcome at baseline; and the coefficient γ_{11} on the interaction term between Year$_{ij}$ and Practices$_j$ which specifies the change in the effects of Practices over time. These 'birth-cohort' models will be applied when examining student outcomes in the birth cohort sample. A logistic link function was used for testing trends in binary outcome measures, and normal link function was used for the continuous measures.

The glimmix procedure was used for statistical analysis (Version 9.1, SAS Institute).

Measures
Student tobacco use, precursors to tobacco use, community programme
Lifetime cigarette use (ever smoked cigarettes), 30-day cigarette use (current smoker), frequent cigarette use (smoking 20 or more days during the past 30 days), and 30-day cigarette use on school property were combined with one cigar smoking measure to create a 'smoking index.' This index is the standardised sum of these four cigarette use measures and one cigar smoking measure (Cronbach's $\alpha=0.68$)

Precursors of smoking such as tobacco use-related attitudes and beliefs were collapsed by positive and negative valence. Emerging research shows that youths hold concurrent positive and negative expectancies about the consequences of health-compromising behaviours, and that the expectancy of positive consequences may be more predictive of those behaviours than expectancy of negative consequences.[22–24] These were kept as multi-point continuous measures and transformed to a common standardised scale (SD [SD]=1.0).

A school-level index of community tobacco control support was constructed by taking the mean of the student reports at each school regarding their participation in or awareness of community tobacco control activities, police enforcement of restrictions on tobacco sales to minors and enforcement of tobacco product possession by minors. The index was standardised and scaled with higher scores indicating a larger proportion of the students at a school were aware of community support for tobacco control.

Tobacco use policies and tobacco control practices
The investigators relied on teacher, school Tobacco Use Prevention Education (TUPE) coordinator, and school administrator survey responses to measure school tobacco use policies and practices. For the teacher reports, measures were calculated by averaging reports across TUPE-experienced teachers within each school. TUPE-experienced teachers were those who reported having taught TUPE lessons in the current school year or at some time during the previous school year. For the schools with no TUPE-experienced teacher respondents, mean responses were reported for all teachers. Appendix II lists, by source of report, the questionnaire items used in this study to inventory tobacco use policies and tobacco control practice measures.

The investigators further constructed multi-item summary indices from these measures by standardising the sum of the items listed in each of the five broad areas of tobacco use prevention/intervention services: (1) no-tobacco use policies, (2) tobacco-related instruction, (3) school-wide anti-tobacco activities, (4) cessation activities and (5) parent involvement. The summary measures used reports from the school tobacco use prevention/intervention coordinators and in the case of the instructional area, additional reports from the teachers who had taught tobacco lessons were used. As mentioned earlier, owing to the possibility of multiple tobacco prevention education activities in schools apart from TUPE, we developed a global implementation index. This index measured TUPE-related activities, not the funding mechanism because many schools that do not have TUPE funding still have tobacco prevention-related activities or classes. As an indicator of TUPE implementation activities, a global implementation index was constructed as the sum of these five component indices listed above. However, competitive TUPE funding status was shown to be associated with increases in TUPE-related activities (result not shown).

TUPE funding status
During the period 2003–2006, only high schools that submitted requests to California Department of Education for tobacco control resources were eligible to receive TUPE funds. Of these eligible schools, only those high schools with competitive applications received TUPE funding. To be competitive, the grant

applications had to address three areas: prevention, intervention, and readiness for cessation and/or cessation strategies. Successful TUPE grantees received up to $37.50 per student based on average daily attendance. There was no relation between high school TUPE funding status and eligibility for inclusion in the school-longitudinal cohort ($\chi^2_{(1)}$=0.27, p=0.606).

RESULTS
Sample characteristics
Table 1 presents basic characteristics of high schools that participated in two consecutive surveys (2003—2004 and 2005—2006). Of the 65 eligible high schools that participated in the 2003—2004 survey, the same 57 schools were surveyed again in 2005—2006.

Overall, average student enrolment size in participating high schools was 2358; the proportion of white, non-Hispanic/Latino (a) students was 43.5%; and female students comprised 51.4% of the sample.

Grade and time trends in tobacco use
Table 2 shows current smoking prevalence, defined as smoking on one or more days in the last 30 days, during the two different survey times by grade. Overall high school prevalence of current smoking significantly increased by 2.6% (p<0.001) from 2003—2004 to 2005—2006. Moreover, current smoking prevalence increased in every grade during this period, by approximately 2.0—3.0%. By contrast, no significant change was found in the overall lifetime smoking prevalence over time during this same period, not for any grade.

Cohort trends in tobacco use and its precursors
Table 3 displays the change in the birth cohort tobacco use-related outcomes over time. Increases were observed in the smoking index, intention to smoke and number of friends smoking in each birth cohort as students moved from grades 9 and 10 to grades 11 and 12. Student estimates of peer smoking increased along with actual increases in perceived smoking prevalence of students in the same grade and the smoking index.

Among the tobacco use-related attitude and belief indices, there were significant decreases in perceived negative social and health consequences of smoking, respectively (p<0.05). The decreases in these protective factors over time were consistent with the observed increases in smoking. Overall, the belief that smoking has a positive social value did not change with age. Also, attitudes towards the tobacco industry among students as they aged remained relatively unchanged.

Impact of TUPE exposure
In the present study, we examined the impact of exposure to the school-based TUPE activities as reflected in the global implementation index, not by TUPE funding status, because even non-TUPE funded schools still can have other federally recommended tobacco prevention activities, as mentioned earlier. The global implementation index was based on data from teachers, district TUPE coordinators and school TUPE coordinators. The impact was measured in two ways: (1) as the cross-sectional association between TUPE implementation exposure and tobacco-related outcomes at baseline; and (2) as the impact of TUPE activity exposure on the birth cohort changes over time in tobacco use-related attitudes and smoking behaviours (table 4). TUPE activity was significantly associated with smoking index increases (p=0.009) and with students' estimates of peer smoking prevalence (p=0.04) at baseline. However, other outcome variables did not show a significant cross-sectional association with TUPE activity.

On the other hand, the level of TUPE implementation at each school was found to affect, over time, the smoking index, intention to smoke and number of friends who smoked. The increased smoking index level for students who moved from the 9th or 10th grade to 11th or 12th grade over 2-year period was found to be reduced by an average of 0.070 SD units (p=0.004) for every one SD unit increase in the global implementation index. Similarly, intentions to smoke were also impacted, with a predicted reduction of 0.059 SD units (p=0.013) for each one SD unit increase in TUPE implementation activities. The change in the reported number of friends who smoked was also reduced by 0.076 SD units (p=0.001) for each 1 SD unit increase in TUPE activities. Somewhat surprisingly, birth cohort changes in the other precursors of smoking examined, such as attitudes about social and health consequences, appeared to be unaffected by student exposure to school TUPE activities.

Effects of TUPE activities and contextual factors on smoking
Table 5 provides the results of the multivariate hierarchical linear model predicting smoking index as an outcome of school-level factors, both cross-sectionally and as a predictor of birth cohort changes in smoking.

The index of community support for tobacco control was associated with smoking in cross-sectional analysis (p<0.01) but not with birth cohort changes in smoking over time (p=0.796). The anti-tobacco media message index was not associated with smoking at baseline (p=0.182) but was associated with increases in smoking over time (p=0.021). Enrolment and an index of school-level socioeconomic factors (average API score, average parent educational attainment, and percentage of students eligible for school lunch subsidies) at each school, were related to lower levels of smoking at baseline, but were associated with higher 2-year birth cohort changes in the prevalence of smoking.

At baseline, school TUPE implementation was not significantly associated with student smoking prevalence (coefficient of 0.020 (p=0.297); table 5). However, the coefficient for the change in this association over time (−0.043, p=0.064) indicated a suggestive benefit of TUPE implementation on reducing student smoking after 2 years. The differences in coefficient estimates between the bivariate model (table 4) and the model adjusted for contextual factors such as school socioeconomic status suggests that these factors may confound the association between school TUPE-related activities and student smoking prevalence. The difference in fit statistics for full model (−2 LL=25852.93) and a reduced model without school TUPE index variable (−2 LL=25861.79) was 8.86, with 2 degrees of freedom (p<0.02).

Table 1 Demographic characteristics of re-surveyed high schools (n=50)

	Total
Female (%)	51.4
Male (%)	48.5
African American (%)	5.4
Hispanic/Latino(a) (%)	34.0
White, non-Hispanic/Latino(a) (%)	43.5
Eligibility of subsidised meals (%)	26.2
Mean of parental education (1=less than high school, 5=graduate degree)	3.1
Mean of academic performance index (standardised achievement test scores)	717
Mean of student enrolment	2358
Number of students (9th to 12th grade)	16 833

The number of students represents an aggregate of students over two survey cycles: 2003—2004+2005—2006.

Table 2 Current and lifetime smoking prevalence by grade, 2003–2004 and 2005–2006

Grade	No	Current smoking prevalence*		Lifetime smoking prevalence†	
		2003–2004 % (95% CI)	2005–2006 % (95% CI)	2003–2004 % (95% CI)	2005–2006 % (95% CI)
9	3839	7.6% (6.2 to 8.9)	10.6% (9.3 to 11.8)	30.2% (27.8 to 32.7)	29.9% (28.1 to 31.8)
10	4827	11.6% (10.2 to 13.0)	14.2% (12.9 to 15.5)	38.2% (36.1 to 40.3)	40.2% (38.3 to 42.0)
11	3930	14.6% (12.7 to 16.6)	16.6% (15.2 to 18.0)	43.4% (40.7 to 46.2)	44.2% (42.3 to 46.1)
12	4237	17.7% (15.6 to 19.7)	20.0% (18.5 to 21.5)	52.9% (50.2 to 55.6)	49.4% (47.5 to 51.2)
Total	16 833	12.8% (12.0 to 13.7)	15.4% (14.7 to 16.0)	41.2% (39.9 to 42.4)	40.9% (40.0 to 41.9)

The number of students represents an aggregate of students over two survey cycles: 2003–2004+2005–2006.
*Current smoking: Smoking in the last 30 days.
†Lifetime smoking: Ever smoked cigarettes, even one or two puffs.

DISCUSSION

California has witnessed continual decreases in the prevalence of current smoking among youths since 1995.[19] [20] However, in 2005–2006 this downward trend in prevalence was reversed and prevalence of current smoking increased. The current analysis confirms that the prevalence of current smoking among high school students increased relative to 2003–2004. In this study, decreases in protective factors were consistent with parallel increases observed in smoking prevalence; factors included perceived negative social and health consequences of smoking over time, an increase in intention to smoke, number of friends who smoke and student perceptions of smoking prevalence among peers.

However, the reason for the observed increase in current smoking prevalence is unclear. It may be due to an underlying cohort effect[25] or to other factors such as a decrease in the real price of cigarettes[26] or decrease of tobacco control mass media messages,[27] which can have a significant impact on youth smoking rates. In addition to these factors, the Centers for Disease Control and Prevention has attributed the lack of decline in national youth smoking prevalence to substantial increases in tobacco industry expenditures on tobacco advertising and promotion in the USA. Tobacco industry expenditure have increased from $5.7 billion in 1997 to $15.2 billion in 2003.[28]

According to the final multivariate model, cross-sectional effects of TUPE implementation activities at baseline showed no association with the smoking index, whereas over the 2-year period, we observed a suggestive change towards a negative association between the level of TUPE activities and the smoking index. Two possible explanations for this pattern of results are that the schools with high tobacco use rates may have been more motivated to apply for TUPE programme funds and to carry out TUPE-related activities that might have resulted in a reduction in smoking or schools with fewer TUPE activities had greater increases in smoking prevalence over time.

The school-level index of perceived community support for tobacco control was examined as one of the contextual factors. Previously, implementation of community-level comprehensive tobacco control strategies has been recommended to reduce youth smoking.[29] [30] The cross-sectional results show that increases in student-reported community support for tobacco control were significantly associated with a lower smoking index. However, the school cohort analysis of change over the two time points did not show a significant association on the change which might imply the effect of community support index on smoking index started getting weakened over time.

Reitsma and Manske noted that student tobacco use varied as a function of the size of the school with smoking rates highest in schools of intermediate size and lowest in the biggest schools.[31] Our study showed that larger school enrolment was associated with a lower smoking index at baseline, whereas the comparison over time showed a significant positive change, indicating that this effect had disappeared by the second time period. Generally, small schools are less likely to apply for competitive grants of any kind, because they tend not to have enough staff members with time dedicated to writing grants. Therefore, a significant change to the positive direction in the association could reflect real increased trends in the risk of students becoming smokers because reductions in TUPE activities over time may have been greater in large schools than in small schools, which would make no difference in smoking prevalence between small and large schools.

Similar trends were seen with the school socioeconomic context index, which was constructed from combining average parent education levels, Academic Performance Index (API) scores, and percentage of students eligible for federal lunch subsidies at each school. High family socioeconomic status (SES),[32] [33] positive parental influence[34] and students' academic performance[35] [36] are recognised as important protective influences with respect to health behaviours such as alcohol drinking, smoking and drug use. It was therefore expected that these components of the measure of school socioeconomic context in the present study would at least partially explain a preventive influence on student smoking behaviour. However, the significant positive change in the association between the school socioeconomic context index and the smoking index over time implies a weakening of the effect and, we found nearly no difference by the second year which is counter-intuitive and

Table 3 Time trends in tobacco use and its precursors

Outcomes	Change in outcome over time	
	γ Coefficient (SE)*	p Value
Smoking index	0.268 (0.019)	0.001
Intention to smoke	0.130 (0.019)	0.001
Friends smoking	0.177 (0.019)	0.001
Perception of smoking prevalence in the same grade	0.207 (0.019)	0.001
Positive social consequences	0.003 (0.019)	0.854
Negative social consequences	−0.237 (0.019)	0.001
Positive health consequences	−0.041 (0.020)	0.041
Negative health consequences	−0.055 (0.019)	0.006
Pro-tobacco industry attitude	0.012 (0.019)	0.518
Anti-tobacco industry attitude	−0.015 (0.019)	0.429

Values are the average change in outcome index values as students moved between grades 9 and10 to grades 11 and 12.
*γ One-zero (γ_{10}) in equation 2.

Table 4 Effects of tobacco use prevention education (TUPE) implementation activities on tobacco use and other precursors (bivariate analyses)

Association of outcome with level of TUPE implementation	Cross-sectional associations of TUPE implementation with the outcome at baseline		Changes in the impact of the TUPE implementation on the outcome	
Outcome	γ coefficient (SE)*	p Value	γ coefficient (SE)†	p Value
Smoking index	0.049 (0.019)	0.009	−0.070 (0.022)	0.004
Intention to smoke	0.030 (0.019)	0.114	−0.059 (0.022)	0.013
Numbers of friends smoking	0.037 (0.019)	0.051	−0.076 (0.022)	0.001
Perception of smoking prevalence in the same grade	0.041 (0.020)	0.040	−0.021 (0.023)	0.354
Positive social consequences	−0.002 (0.018)	0.911	−0.020 (0.023)	0.374
Negative social consequences	−0.003 (0.018)	0.867	0.019 (0.023)	0.390
Positive health consequences	−0.014 (0.017)	0.410	−0.005 (0.022)	0.853
Negative health consequences	−0.012 (0.018)	0.505	0.029 (0.023)	0.208
Pro-tobacco industry attitude	0.011 (0.018)	0.541	−0.018 (0.022)	0.414
Anti-tobacco industry attitude	0.004 (0.019)	0.833	0.001 (0.023)	0.933

Values are the effect of a one unit change in the predictor, TUPE implementation, measured as a global implementation index.
*γ zero-one (γ_{01}) in equation 4.
†γ one-one (γ_{11}) in equation 4.

warrants further research. It is possible that students with high socioeconomic status are more able to afford to buy tobacco products despite of increased prices compared to those with low socioeconomic status, and we observed by the second year distributions of smoking index among high SES groups was similar to that in low SES (data not shown).

When we controlled for other factors, including community tobacco control context, we found that higher student exposure to anti-tobacco media messages was associated with increased smoking prevalence. This change towards more positive direction of observed association was significant over the 2-year period, but was not significant at baseline. This finding is not surprising because never-smokers have been shown to be generally less attentive to commercial and public service tobacco-related messages compared to current smokers.[37][38] Additionally, media exposure may be related to other factors that are not in the model, such as rural or urban geographic status. Also, the present analysis was about school effects as a main exposure of interest, rather than media effects, and only four questions were used for the anti-media index, which were not specifically targeted anti-media questions. To test the impact

of media on smoking prevalence, we would have collected and used very different measures, such as student ratings of specific commercial tobacco advertisements.

There are some limitations to be addressed in this study. While the same schools were followed for two consecutive surveys, the same students were not necessarily sampled. Hence, we assume individual students at the same school followed the same developmental trajectory—for instance, social and physical development. Although differential changes in development among individuals within the same school are unlikely to be dramatic, the possibility of bias should be taken account for interpretation of the results. In addition (appendix I), eight schools were lost to follow-up at the second cycle of survey, and we found more white students and high SES groups were in those losses. However, student level demographic as well as school level SES covariates were controlled in the model. In any case, the distributions of ethnicity and smoking prevalence among the remaining cohort schools (n=57) were similar to those of the 91 non-carry high schools that participated in the 2003−2004 survey. We believe that it is less likely to introduce biases by differential attrition by ethnicity and related SES.

All student data were obtained from in-school students volunteering to complete self-reported questionnaires. Thus, self-report bias and non-participation by high school dropouts may have contributed to underestimating the true smoking prevalence among California high school students.[35] Also, even though TUPE was implemented in small schools, we chose to conserve our limited evaluation resources by restricting the cohort study sample to schools with at least 50 students per school enrolled from the original sampling frame. As a result, our findings may not apply to schools with enrolment smaller than 50 students per school.

The main strengths of the present study are the large sample size and the use of TUPE implementation data collected from teachers and school administrators that yielded valid and reliable measures of TUPE activities. In addition, the use of a repeated cross-sectional design provides an efficient and minimally biased estimator of change at a much lower cost than would be required with longitudinal cohort design.[39]

Even after controlling for potentially biasing contextual factors, these results revealed a marginally significant association

Table 5 Effects of external factors on smoking index (multivariate hierarchical linear regression model)

Predictor	Cross-sectional effects on smoking index at baseline*		Changes in the impact of predictor on smoking index over time†	
	γ Coefficient (SE)	p Value	γ Coefficient (SE)	p Value
Community support index	−0.062 (0.014)	0.001	−0.005 (0.022)	0.796
Anti-tobacco media messages	0.020 (0.015)	0.182	0.048 (0.021)	0.021
Enrolment	−0.042 (0.022)	0.022	0.045 (0.021)	0.029
School socioeconomic context	−0.108 (0.024)	0.001	0.133 (0.023)	0.001
School TUPE implementation index	0.020 (0.019)	0.297	−0.043 (0.023)	0.064

Smoking index is the standardised sum of four cigarette and one cigar smoking measures (α=0.68)
School socioeconomic context is the standardised sum of parent education, API scores and percentage of students eligible for federal school lunch subsidies (α=0.91)
*γ zero-one (γ_{01}) in equation 4.
†γ one-one (γ_{11}) in equation 4.

What this paper adds

Prospective examination of changes in school-average student tobacco use behaviour and related attitudes over a 2-year interval permitted stronger evaluation of programme impact than is possible with cross-sectional data. Our study suggests support for the beneficial effect of TUPE activities over time on reducing student smoking. Results also suggest that evaluation of school-based TUPE needs to consider influences of other comprehensive strategies such as community support for tobacco control.

between school level TUPE activities and decreased smoking index scores over the 2-year period (p=0.06), suggesting that TUPE implementation activities helped to reduce student smoking over time; however, the normally robust inverse association between school-level SES measures and the smoking index became non-significant at the 2-year follow-up, possibly because of increased dropout among low-SES smokers in the 12th grade. Of further concern is the lack of evidence that anti-tobacco media messages had any effect on smoking prevalence among high school students in California.

Regardless of the findings, this study demonstrates how a relatively low-cost, practical evaluation design can be used to assess longitudinally the impact of school-based tobacco control intervention activities on student smoking prevalence.

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APPENDIX I

DESCRIPTIVE STATISTICS FOR TOTAL 2003–2004 CALIFORNIA STUDENT TOBACCO SURVEYS (CSTS) HIGH SCHOOL SAMPLE, AND FOR CARRYOVER SUBSAMPLE

Sample school/student characteristics

	Non-carryover high schools	High schools that participated in original longitudinal study	Goodness of fit χ^2 test	2005 carryover high schools	2005 dropout carryover high schools	Goodness of fit χ^2 test
School sample size (No of schools)	91	65		57	8	
Student sample size (No of students)	7817	7211		6301	910	
School grade			p=0.0700			p=0.2323
9	27.0%	30.2%		22.6%	21.1%	
10	21.5%	31.6%		25.8%	32.3%	
11	27.2%	19.9%		24.9%	19.5%	
12	23.1%	18.3%		26.6%	18.1%	
Gender			p=0.6444			p=0.9900
Female	49.6%	48.0%		47.8%	50.2%	
Male	50.4%	52.0%		52.2%	49.8%	
Ethnicity*			p=0.1533			p=0.0544
American Indian	1.0%	0.9%		1.0%	0.02%	
Asian	11.0%	11.5%		10.8%	20.8%	
African American	11.3%	5.0%		5.0%	5.1%	
Hispanic/Latino(a)	38.2%	35.9%		37.6%	13.0%	
Pacific Islander/Filipino	2.5%	2.0%		2.0%	2.8%	
White	36.0%	44.6%		43.6%	58.3%	
Tobacco use status						
Lifetime use	45.8%	39.7%	p<0.0456	39.7%	40.1%	p=0.0774
Current use (any smoking in 30 days)	12.5%	13.2%	p=0.6306	13.0%	15.4%	p=0.0405

Source: 2003–2004 CSTS data weighted to reflect the complex survey design and corrected for differential non-response.
*CSTS ethnicity prevalence estimates are based on a question asking respondents to identify one ethnic category that best describes her/himself.

APPENDIX II

DATA SOURCES FOR SCHOOL-LEVEL TOBACCO USE POLICY AND PRACTICE MEASURES

	Teacher	Coordinator	Administrator
Tobacco policy			
Enforcement of no-use policy	√	√	
Consequences of violation	√	√	√
Tobacco-related instruction			
Lessons taught	√	√	
Hours of instruction	√	√	
Infusion of tobacco lessons into other subjects	√		
Published curriculum	√		
Topics covered	√	√	
Mode of delivery	√	√	
Training	√	√	
Barriers to teaching lessons	√	√	√
School-wide anti-tobacco activities			
Number of school-wide activities	√	√	√
Cessation activities			
Presence of cessation services for students	√	√	
Referral of smokers to 800-NO-BUTTS hotline	√	√	√
Parent involvement			
Involvement of parents in TUPE activities	√	√	√