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Nonmedical exemptions to immunization requirements in California: A 16-year longitudinal analysis of trends and associated community factors

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Abstract

Background—Rates of nonmedical exemptions to kindergarten-entry immunization requirements have increased over the past 2 decades, especially in states that permit philosophical exemptions and/or have easier administrative policies for obtaining nonmedical exemptions. We evaluated trends in school personal belief exemption rates over the period 1994–2009 in California, and associated school and community characteristics.

Methods—We used data on personal belief exemptions from 6392 public and private elementary schools from the California Department of Public Health, as well as census tract and school demographic data. Generalized estimating equations were used to model annual mean increases in personal belief exemption rates, and to identify school and community characteristics associated with personal belief exemption rates.

Results—Over the study period, the average school personal belief exemption rate increased from 0.6% in 1994 to 2.3% in 2009, an average of 9.2% (95% CI: 8.8–9.6%) per year. The average personal belief exemption rate among private schools over the entire study period was 1.77 (95% CI: 1.55–2.01) times that among public schools. The annual rate of increase was slightly higher among private schools (10.1%, 95% CI: 9.1–11.1%) than among public schools (8.8%, 95% CI: 8.4–9.2%). Schools located within census tracts classified as rural had 1.66 (95% CI: 1.26–2.08) times higher personal belief exemption rates than schools located within urban census tracts. Exemption rates were also associated with race, population density, education, and income.

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Conflict of interest

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Conclusions—This study confirms concerns about increasing rates of nonmedical exemptions to kindergarten vaccine requirements within the state of California, using data collected over a 16-year period.

Keywords

Vaccines; Immunization; Exemption; School mandate

1. Introduction

All U.S. states and the District of Columbia (DC) have state laws that require children to receive routine immunizations before entering kindergarten. In all states, medical exemptions are granted when vaccines are contraindicated for medical reasons. In 48 states and DC, parents can also obtain nonmedical exemptions if they oppose immunization on religious or philosophical grounds. Non-medical exemption rates increased between 1994 and 2011, especially in states that permit philosophical exemptions and/or have less complicated administrative policies for obtaining nonmedical exemptions [1–4]. California permits personal belief exemptions to kindergarten school entry immunization requirements; at the state level, the personal belief exemption rate increased from 1.2% to 2.3% between the 2004–2005 and 2010–2011 school years [2].

There are growing concerns about parental vaccine refusal, especially in light of state-level increases in kindergarten nonmedical exemption rates, and recent outbreaks of vaccine-preventable diseases (e.g., measles, pertussis) [1,5]. Factors associated with geographic clustering of nonmedical exemptions include: school policies for obtaining nonmedical exemptions, beliefs about immunization among school personnel responsible for implementing policies, higher population density, higher percentage of racial/ethnic minorities, higher percentage of children <5 years, and larger family size [5–7].

There are few published findings evaluating community characteristics associated with nonmedical exemption rates. This study used data on personal belief exemption rates by school for kindergarten classes in California schools between 1994 and 2009. We evaluated trends in personal belief exemption rates over time, and the association of school and community characteristics with changes in personal belief exemption rates.

2. Materials and methods

We obtained data on personal belief exemptions and kindergarten enrollment for all California public and private schools that enroll 10 or more kindergartners per year from the California Department of Public Health (CDPH). The study period comprised school years 1994–1995 through 2009–2010. The number of personal belief exemptions for each school reflected the total number of students who had a personal belief exemption for any vaccine, based on required vaccines for the study year. We computed the annual personal belief exemption rate by dividing the number of personal belief exemptions by total kindergarten enrollment in that school for each year.

We geocoded schools to California census tracts using geographic positioning system coordinates, and assigned schools the demographic characteristics of the census tracts in which they were located. We obtained publicly available data on the following census tract demographic variables from the U.S. Census Bureau (2000 data): population density, average family size, racial distribution (proportion of population that was white), proportion of population with college degree, median household income, proportion of families with children under age 5 in poverty, proportion of the population aged less than 5 years, proportion of population that spoke a primary language other than English, and proportion of population that was unemployed. We also obtained data on public/private school status and degree of urbanicity (defined as Rural Urban Commuting Area (RUCA) code, which characterizes zip codes according to their rural and urban status) [8].

Personal belief exemptions and kindergarten enrollment were measured as counts. All analyses used generalized estimating equations (GEE) based on the negative binomial distribution, treating each school as a repeated cluster. Kindergarten enrollment for each school year was used as the population denominator to calculate the personal belief exemption rate and was used as the offset term in GEE models. We used a stationary 15-dependent correlation structure to account for within-cluster correlation between observations over the 16-year study period. First, we modeled the annual mean increase in personal belief exemption rate over the study period across all schools. We then stratified these analyses by public versus private school, California Postsecondary Education Commission (CPEC) regions of California, and time period (1994–1999 versus 2000–2009).

Additionally, we used GEE models based on the negative binomial distribution to obtain incidence rate ratios comparing mean personal belief exemption rates between public and private schools and between time periods (1994–1999 versus 2000–2009) in California overall and within each region. Then, we used GEE models based on the negative binomial distribution to model the associations between school and community characteristics and personal belief exemption rates. From an initial model containing all a priori predictors (census tract demographic variables, public/private school, and RUCA code), we removed predictors that contributed to collinearity. Collinearity was assessed using condition indices and variance decomposition proportions, using a SAS macro for GEE models [9]. Then, we used a backwards elimination strategy to choose our final model, removing variables that were not significant at $p < 0.05$.

Statistical analyses were performed using SAS v9.3 (Cary, NC). School addresses were geocoded using ArcGIS v10 (ESRI, Redlands, CA). Results were considered significant at $\alpha = 0.05$.

The data were obtained from CDPH in two stages. First, 1994–2003 data were obtained and use of the data for this study was approved by the Emory University Institutional Review Board (IRB) and the CDPH IRB. Subsequently, 2004–2009 data were obtained; use of those data for this study was approved by the Emory University IRB and deemed non-human subjects research by the CDPH IRB.

3. Results

There were a total of 126,756 school years of data representing 11,032 schools in our study period. We excluded schools based on the following criteria: could not be geocoded and matched to demographic data ($n = 1358$ school years), had more than one personal belief exemption count entered for the same year (i.e., duplicated data or mislabeled entries) ($n = 182$ school years), located within census tracts with zero households ($n = 33$ school years), or could not be identified as public or private school ($n = 19,814$ school years). We also excluded schools with less than 10 school years of data ($n = 6530$ school years). Therefore, our final dataset included a total of 98,839 school years of data representing 6392 schools over 16 years. Results from the dataset with incomplete follow-up were similar to those from the analytic dataset (analyses available upon request).

The average school personal belief exemption rate increased over the study period from 0.6% in 1994 to 2.3% in 2009, an average annual increase of 9.2% (95% CI: 8.8, 9.6%) (Tables 1 and 2, Fig. 1). The average annual increase in school personal belief exemption rates significantly increased in all California Postsecondary Education Commission (CPEC) regions, and was heterogeneous across regions (Table 2). The regions with the highest average annual increase in personal belief exemption rate were: Los Angeles (12.0% [95% CI: 11.0%, 13.0%] representing an increase from 0.4% in 1994 to 1.1% in 2009), Orange County (11.9% [95% CI: 10.5%, 13.4%] representing an increase from 0.7% in 1994 to 1.6% in 2009), and San Francisco Bay (10.9% [95% CI: 9.9%, 11.8%] representing an increase from 0.7% in 1994 to 1.7% in 2009). The regions with the lowest average annual increase in personal belief exemption rate were: Inland Empire (3.7% [95% CI: 2.4%, 5.0%] representing an increase from 0.7% in 1994 to 1.1% in 2009), Central Coast (7.0% [95% CI: 5.2%, 8.8%] representing an increase from 1.8% in 1994 to 3.2% in 2009), and South San Joaquin Valley (7.1% [95% CI: 5.5%, 8.8%] representing an increase from 0.5% in 1994 to 1.1% in 2009). Mean personal belief exemption rates over the entire study period were highest in the Superior California (4.5%) and North Coast (4.1%) regions.

Mean personal belief exemption rates were significantly higher during 2000–2009 as compared to 1994–1999 in all CPEC regions (Table 2). Overall, the mean personal belief exemption rate over the period 1994–1999 was 0.8% compared to 1.7% during 2000–2009. In the Inyo Moyo, Superior California, Los Angeles, and Upper Sacramento Bay regions, the average personal belief exemption rate during 2000–2009 was more than twice as high as during 1994–1999. Across all California regions, mean personal belief exemption rates were 1.83 (95% CI: 1.77, 1.88) times higher during the 2000–2009 time period than during the 1994–1999 time period (Table 2).

Personal belief exemption rates increased at a significantly higher rate among private schools than among public schools over the study period (Tables 1 and 3, Fig. 1). Among private schools, the average school personal belief exemption rate increased from 0.9% in 1994 to 3.4% in 2009, an average annual increase of 10.1% (95% CI: 9.1%, 11.1%). In comparison, the average school personal belief exemption rate among public schools increased from 0.6% in 1994 to 2.0% in 2009, an average annual increase of 8.8% (95% CI:

8.4%, 9.2%). Over the study period, the average rate of personal belief exemptions among private schools was 1.77 (95% CI: 1.55, 2.01) times higher than among public schools.

In the final adjusted model, census tracts classified as “rural” had 1.66 (95% CI: 1.26, 2.08) times the rate of personal belief exemptions compared to “urban” areas over the study period (Table 4). For each 1% increase in the proportion of the census-tract population self-identifying as “white” race/ethnicity, the average personal belief exemption rate increased by 2.8% (95% CI: 2.4%, 3.2%). For each 1% increase in the proportion of the census-tract population with college education, the average personal belief exemption rate increased by 1.9% (95% CI: 1.4%, 2.2%). In contrast, for each 1000-person increase in population per square mile, the average personal belief exemption rate decreased by 3.3% (95% CI: 2.1%, 4.5%). For each \$10,000 increase in median household income, the average personal belief exemption rate decreased by 8.6% (95% CI: 5.3%, 11.7%). The remaining covariates were dropped due to multicollinearity or due to non-significance.

4. Discussion

This study confirms growing concerns about increasing rates of nonmedical exemptions to kindergarten vaccine requirements, using a comprehensive dataset covering California schools from 1994 through 2009. Personal belief exemption rates increased in California over the 16-year period, and average rates of increase varied by region and between public and private schools. These findings demonstrating sustained increases in personal belief exemption rates highlight the need for state-level policies that minimize rates of nonmedical exemptions. States with policies making it more difficult for parents to obtain nonmedical exemptions have been shown to have lower nonmedical exemption rates – and lower rates of increase in nonmedical exemptions over time – than states with less complicated administrative requirements [3]. At the time of this report, the state of California recently passed legislation (A.B. 2109) that will require parents seeking a personal belief exemption to submit a statement signed by a healthcare practitioner indicating that they have received information about risks and benefits of vaccines, starting in 2014 [10]. Our findings provide critical evidence highlighting the importance of this legislation in addressing increasing rates of personal belief exemptions in California.

Further, we identified community characteristics that are positively and negatively associated with personal belief exemption rates among California schools. Our findings that certain community characteristics are associated with personal belief exemption rates add insight into current understanding of geographic clustering of vaccine refusal. Schools with higher rates of personal belief exemptions were located in communities with higher proportions of the population of white race, higher proportions of the population college-educated, and were more likely to be located in rural than urban areas. Schools with higher rates of exemptions were located in communities that had lower population density, and lower median household income. We also found that the mean annual increase in personal belief exemption rates varied across California regions, demonstrating within-state heterogeneity in exemption rate trends. This finding is further evidence of within-state geographic heterogeneity in nonmedical exemption rates, as previously found in Oregon, Washington, and Michigan [5,11,12].

While it has been previously shown that nonmedical exemption rates are higher among private schools [6], this is the first study to evaluate differences in longitudinal trends in nonmedical exemption rates between public and private schools. Our findings suggest that not only are nonmedical exemption rates higher on average among private schools, but they are also increasing faster. Further investigation of differences in public- and private-school nonmedical exemption rates is warranted in order to develop appropriate interventions addressing vaccine refusal and exemption rates among different types of schools. State-level administrative procedures for obtaining nonmedical exemptions may be implemented in different ways across school types, and there may be important differences in demographics of populations attending public and private schools.

The major strength of our study was the comprehensive nature of our dataset: we obtained data on all schools that enrolled kindergartners over the period 1994–2009. Using these data, we were able to obtain precise and accurate estimates of longitudinal changes in exemption rates, as well as associations of community factors with exemption rates. However, there is a possibility of selection bias due to our decision to evaluate only schools that had data for all years in the study period and that were not missing values for any covariates. Further, our dataset contained information only on whether a nonmedical exemption was obtained for any vaccine; data were not available on exemptions for specific vaccine antigens. Hepatitis B and varicella vaccines were added to required kindergarten immunizations over the study period (in 1997 and 2001, respectively) [13], which may have contributed to the increase in number of nonmedical exemptions for any vaccine. However, in an earlier analysis of longitudinal trends in immunization exemption rates, adjusting for new hepatitis B and varicella vaccine requirements had little impact on results [1]. Our study may be limited by our assignment of community characteristic data to schools by census tract, because census tract information may not always reflect individual schools' communities. However, in this study, we have not made inferences at the individual level (e.g., for individual students attending schools in our study) regarding tendency to obtain personal belief exemptions.

5. Conclusions

Our findings demonstrate increasing rates of nonmedical exemptions, and heterogeneity among school types and rural versus urban communities. Understanding community characteristics associated with nonmedical exemption rates is critical for developing interventions to address vaccine refusal. In order to maximize effectiveness, such interventions should focus on high risk areas and, more specifically, should prioritize private schools.

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Abbreviations

CDPH California Department of Public Health

RUCA	Rural Urban Commuting Area
GEE	generalized estimating equation
IRB	Institutional Review Board
CPEC	California Postsecondary Education Commission

References

1. Omer SB, Pan WK, Halsey NA, Stokley S, Moulton LH, Navar AM, et al. Nonmedical exemptions to school immunization requirements: secular trends and association of state policies with pertussis incidence. *JAMA*. 2006; 296(14):1757–63. [PubMed: 17032989]
2. U.S. Centers for Disease Control and Prevention. Vaccination coverage and surveillance: annual school assessment reports. <http://www.cdc.gov/vaccines/stats-surv/schoolsurv/assessment-reports.htm>. [accessed 16.04.12]
3. Omer SB, Richards JL, Ward M, Bednarczyk RA. Vaccination policies and rates of exemption from immunization, 2005–2011. *NEJM*. 2012; 367(12):1170–1. [PubMed: 22992099]
4. Rota JS, Salmon DA, Rodewald LE, Chen RT, Hibbs BF, Gangarosa EJ. Processes for obtaining nonmedical exemptions to state immunization laws. *Am J Public Health*. 2001 Apr 4.91:645–8. [PubMed: 11291383]
5. Omer SB, Enger KS, Moulton LH, Halsey NA, Stokley S, Salmon DA. Geographic clustering of nonmedical exemptions to school immunization requirements and associations with geographic clustering of pertussis. *Am J Epidemiol*. 2008; 168(12):1389–96. [PubMed: 18922998]
6. Salmon DA, Omer SB, Moulton LH, Stokley S, Dehart MP, Lett S, et al. Exemptions to school immunization requirements: the role of school-level requirements, policies, and procedures. *Am J Public Health*. 2005; 95(3):436–40. [PubMed: 15727973]
7. Salmon DA, Moulton LH, Omer SB, Chace LM, Klassen A, Talebian P, et al. Knowledge, attitudes, and beliefs of school nurses and personnel and associations with nonmedical immunization exemptions. *Pediatrics*. 2004; 113(6):e552–9. [PubMed: 15173536]
8. United States Department of Agriculture Economic Research Service. Rural–urban commuting area codes. <http://www.ers.usda.gov/Data/RuralUrbanCommutingAreaCodes/>
9. Kleinbaum, DG., Klein, M. Logistic regression: a self-learning text. New York, NY: Springer Publishing Company; 2010.
10. California Assembly Bill No. 2109: an act to amend Section 120365 of the Health and Safety Code, relating to communicable disease. 2012. http://www.leginfo.ca.gov/pub/11-12/bill/asm/ab_2101-2150/ab_2109_bill_20120930_chaptered.pdf [accessed 3.10.2012]
11. Omer SB, Salmon DA, Orenstein WA, deHart MP, Halsey N. Vaccine refusal, mandatory immunization, and the risks of vaccine-preventable diseases. *N Engl J Med*. 2009; 360(19):1981–8. [PubMed: 19420367]
12. Gaudino JA, Robison S. Risk factors associated with parents claiming personal-belief exemptions to school immunization requirements: Community and other influences on more skeptical parents in Oregon, 2006. *Vaccine*. 2012; 30(6):1132–42. [PubMed: 22178105]
13. California Department of Public Health. Shots for schools. 2010. <http://www.shotsforschool.org/immunizationlaws/> [accessed 1.09.12]

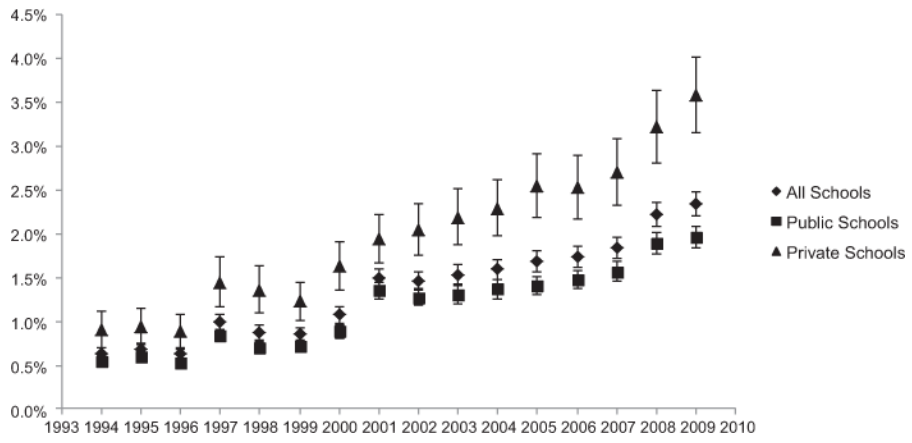


Fig. 1. Average school personal belief exemption rates overall and by school type, 1994–2009.

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Table 1

Longitudinal trends in personal belief exemption rates, 1994–2009, overall and by school type.

Year	Overall	N	Personal belief exemption rate, mean % (95% CI)			
			Public	Private	Overall	Public schools
1994	5893	4411	1482	0.64 (0.58, 0.70)	0.55 (0.50, 0.60)	0.91 (0.71, 1.11)
1995	6006	4486	1520	0.69 (0.62, 0.75)	0.60 (0.55, 0.65)	0.94 (0.74, 1.14)
1996	6022	4497	1525	0.62 (0.56-0.69)	0.53 (0.48, 0.59)	0.89 (0.69, 1.08)
1997	6087	4534	1554	0.99 (0.90, 1.08)	0.83 (0.77, 0.90)	1.45 (1.16, 1.73)
1998	6111	4561	1551	0.87 (0.79, 0.95)	0.71 (0.65, 0.77)	1.36 (1.09, 1.63)
1999	6261	4675	1587	0.85 (0.78, 0.92)	0.72 (0.66, 0.79)	1.23 (1.01, 1.45)
2000	6350	4748	1603	1.07 (0.98, 1.17)	0.88 (0.80, 0.97)	1.64 (1.37, 1.91)
2001	6367	4750	1618	1.50 (1.40, 1.60)	1.35 (1.25, 1.45)	1.94 (1.67, 2.22)
2002	6353	4745	1609	1.47 (1.37, 1.57)	1.27 (1.18, 1.37)	2.05 (1.75, 2.34)
2003	6346	4743	1604	1.53 (1.41, 1.65)	1.31 (1.19, 1.42)	2.19 (1.87, 2.52)
2004	6209	4704	1506	1.59 (1.48, 1.70)	1.36 (1.26, 1.47)	2.30 (1.98, 2.62)
2005	6182	4695	1488	1.69 (1.61, 1.85)	1.32 (1.31, 1.52)	2.54 (2.18, 2.90)
2006	6206	4706	1500	1.73 (1.61, 1.85)	1.48 (1.37, 1.58)	2.54 (2.17, 2.89)
2007	6134	4675	1459	1.84 (1.72, 1.96)	1.57 (1.46, 1.68)	2.70 (2.32, 3.08)
2008	6212	4706	1506	2.22 (2.08, 2.36)	1.89 (1.77, 2.02)	3.23 (2.82, 3.64)
2009	6090	4674	1417	2.34 (2.20, 2.48)	1.96 (1.84, 2.08)	3.59 (3.15, 4.03)

Table 2

Longitudinal trends in personal belief exemption rates in California, 1994–2009, by California Postsecondary Education Commission (CPEC) region.

California region	Region-years (N)	Annual change in personal belief exemption rate	Personal belief exemption rate, mean % (95% CI)			Incidence rate ratio, by time period (2000–2009 versus 1994–1999) (95% CI)
			1994–2009	1994–1999	2000–2009	
North Coast	1020	1.080 (1.056, 1.105)	4.12 (3.60, 4.64)	2.64 (1.85, 2.98)	5.10 (4.35, 5.84)	1.708 (1.375, 2.122)
Superior California	1019	1.102 (1.067, 1.138)	4.47 (3.96, 4.98)	3.19 (1.43, 2.07)	6.10 (5.34, 6.86)	2.704 (2.098, 3.486)
Upper Sacramento Valley	1080	1.081 (1.043, 1.121)	2.66 (2.38, 2.94)	1.55 (1.16, 1.94)	3.28 (2.91, 3.65)	2.070 (1.486, 2.883)
Sacramento Tahoe	6554	1.077 (1.063, 1.092)	2.13 (2.00, 2.26)	1.34 (1.16, 1.51)	2.59 (2.41, 2.77)	1.602 (1.433, 1.791)
San Francisco Bay	19,483	1.109 (1.099, 1.118)	1.31 (1.25, 1.37)	0.71 (0.65, 0.78)	1.66 (1.57, 1.75)	1.962 (1.820, 2.116)
Monterey Bay	1943	1.088 (1.073, 1.103)	2.80 (2.48, 3.12)	1.58 (1.25, 1.90)	3.50 (3.03, 3.96)	1.993 (1.728, 2.298)
North San Joaquin Valley	8866	1.095 (1.083, 1.108)	1.09 (1.02, 1.17)	0.63 (0.56, 0.70)	1.39 (1.28, 1.50)	1.953 (1.751, 2.178)
South SanJoaquin Valley	3768	1.071 (1.055, 1.088)	0.89 (0.82, 0.97)	0.53 (0.45, 0.61)	1.10 (1.00, 1.20)	1.900 (1.658, 2.177)
Inyo Mono	109	1.088 (1.030, 1.149)	1.42(0.83, 2.01)	0.38 (0.07, 0.69)	2.07 (1.16, 2.98)	4.118 (1.509, 11.23)
Central Coast	4441	1.070 (1.052, 1.088)	2.68 (2.50, 2.87)	1.76 (1.48, 2.04)	3.21 (2.97, 3.45)	1.846 (1.634, 2.086)
Inland Empire	9049	1.037 (1.024, 1.050)	0.93 (0.88, 0.98)	0.69 (0.62, 0.75)	1.07 (1.00, 1.13)	1.302 (1.188, 1.428)
Los Angeles	25,436	1.120 (1.110, 1.130)	0.83 (0.79, 0.87)	0.43 (0.39, 0.48)	1.07 (1.01, 1.13)	2.134 (2.003, 2.274)
Orange County	8025	1.119 (1.105, 1.134)	1.25 (1.18, 1.32)	0.68 (0.60, 0.76)	1.57 (1.47, 1.68)	1.729 (1.586, 1.885)
San Diego/Imperial	8046	1.085 (1.075, 1.095)	1.59 (1.50, 1.68)	0.94 (0.85, 1.03)	1.96 (1.83, 2.08)	1.691 (1.579, 1.810)
All Regions	98,839	1.092 (1.088, 1.096)	1.36 (1.33, 1.38)	0.78 (0.75, 0.81)	1.69 (1.66, 1.73)	1.827 (1.774, 1.881)

Notes: Data presented are annual changes in statewide average personal belief exemption rates and comparison of average personal belief exemption rates pre- and post- 2000, overall and by California Postsecondary Education Commission (CPEC) region. All models are generalized estimating equations (GEE) models based on the negative binomial distribution to account for overdispersion and using an m-dependent(15) correlation structure, using state as clustervariable.

Table 3

Longitudinal trends in personal belief exemption rates in California by school type, 1994–2009.

School type	State-years (N)	Annual change in average personal belief exemption rate	Incidence rate ratio (95% CI)
Public	74,310	1.088 (1.084,1.092)	
Private	24,529	1.101 (1.091, 1.111)	
Overall	98,839	1.092 (1.088, 1.096)	

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Table 4

Characteristics associated with average school personal belief exemption rates in California, 1994–2009.

Censustract/school characteristic	Incidence rate ratio, by characteristic (95% CI)
Percent white (1% increase)	1.028 (1.024, 1.032)
Population per square mile (1000 person increase)	0.967 (0.955, 0.979)
Percent with college education (1% increase)	1.019 (1.014, 1.023)
Median household income (\$10,000 increase)	0.914 (0.883, 0.947)
Private school (versus public)	1.774 (1.519, 2.071)
<i>RUCA classification^{a,b}</i>	
Urban	1 (reference)
Micro	1.115 (0.954, 1.304)
Small town	1.122 (0.841, 1.497)
Rural	1.662 (1.263, 2.083)

^aRUCA, Rural Urban Community Area code.

^bConstruct p-value for RUCA classification was $p = 0.010$ based on score equation chunk test.