Exposure to personal belief exemptions from mandated vaccines among California kindergarteners, 2008-2010

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ABSTRACT

Personal belief exemptions (PBEs) from mandated school vaccinations have risen in California over the past decade. Disease outbreaks in the state are thought to be associated with clusters of intentionally unvaccinated children. However, no previous studies have quantified the clustering of PBEs within California schools. This study employs measures from the residential racial segregation literature to assess the extent of and trends in exposure of California kindergarteners to PBEs at school. Using data from the California Department of Public Health, we calculate exposure and isolation indices for the state and by county. Results indicate that more than 20,000 kindergarteners in California attend schools with epidemiologically worrisome rates of PBEs. Trends point to increased exposure over time, but not increased concentration of children with PBEs within schools. Schools with a high prevalence of intentionally unvaccinated children are epidemiologic "hotspots" and should be the focus of policy and programmatic interventions.

BACKGROUND

Personal belief exemptions (PBEs) from school vaccination requirements have risen in California over the past decade, part of a nationwide trend of increased parental hesitancy around the childhood vaccination schedule and increased resistance to vaccine mandates. Recent outbreaks of measles, pertussis, and varicella in the state have been linked to clusters of intentionally unvaccinated children in schools. For example, a 2008 outbreak of measles in San Diego was centered around a school with the highest PBE rate in the county.

The rising rate of personal belief exemptions in California and in other states has been well-documented. Less studied, however, is the extent of and trends in the social and spatial clustering of non-vaccination. In order to preserve herd immunity against vaccine-preventable childhood diseases, it is crucial to maintain high levels of immunization coverage not only at a population level, but also within subgroups or locations where children spend the majority of their time, such as school classrooms. In this study, we use school-level data from California from 2008-2010 to assess both exposure to and clustering of PBEs. Using exposure measures originally developed to analyze residential racial segregation, we ask three questions:

1) How many California kindergarteners attend schools with PBE rates high enough to indicate epidemiologic risk of an outbreak?

2) What is the average exposure to PBEs among kindergarteners who do not have exemptions from the mandated schedule?
3) What is the average exposure to PBEs among kindergarteners who do have PBEs?

For each question, we examine statewide trends from 2008-2010, as well as county-level differences in 2010. Our results suggest increasing exposure but not increased clustering of exemptions within schools. We provide a concrete set of metrics for public health and education officials to target epidemiologic "hotspots" that should be the focus of policy and programmatic interventions.

METHODS

The study uses publically-available data from the California Department of Public Health (CDPH) for the school years 2008-09, 2009-10, and 2010-11. Each school offering kindergarten reports to the CDPH total kindergarten enrollment and the number of students in each vaccination category: up-to-date on mandated vaccines, permanent medical exemption, conditional acceptance, or personal belief exemption. In order to receive a personal belief exemption for a child entering school in California, a parent simply signs a two-sentence affidavit that appears on the back side of the official California School Immunization Record (reproduced as Figure 1). Conditional acceptance is offered to students who are not up-to-date on mandated vaccinations but plan to complete the required schedule in the near future.

Our compiled dataset includes more than 7,000 public and private schools and around 500,000 kindergarteners in each of the three years (see Table 1). Schools with kindergarten enrollment of less than 10 are not included in the publically-available data. For each year, we calculate the PBE rate as the number of kindergarteners with PBEs (hereafter, KXs) divided by the total number of kindergartners (hereafter, Ks). We next calculate the distribution of KXs and Ks across schools with different PBE rates: 0%, 0.1%-9.9%, and 10% or higher. We choose 10% as a conservative threshold for a high or epidemiologically worrisome PBE rate based on the reproductive rate of measles and the threshold level of immunization required in a population to prevent a measles outbreak (94-95%).

We then calculate two measures of exposure to PBEs in school, both taken from the literature on residential racial segregation. The isolation index (P*) measures the probability that a KX will encounter another KX at school, and is calculated as the KX-weighted average of the KX proportion in each school:

$$P^* = \sum_{i=1}^{N} \left[\left(\frac{x_i}{X} \right) \left(\frac{x_i}{k_i} \right) \right]$$

where x_i is the number of KXs in school i, X is the total number KXs, and k_i represents the total kindergarten enrollment in school i. The index runs from 0 to 100, and can be interpreted as the average school PBE rate for KXs. A high P* value indicates that KXs are very likely to be exposed the other KXs. As KXs are much less likely to be

vaccinated than children without exemptions, the risk of an outbreak is greater in schools with high isolation.

The second measure of clustering we use is the exposure index, which captures the probability that a kindergartener without an exemption, (hereafter, KA for "adherence" to the vaccine mandate) will be exposed to a KX at school.

$$Exposure \quad = \sum_{i=1}^{N} \left[\left(\frac{a_i}{A} \right) \left(\frac{x_i}{k_i} \right) \right]$$

where a_i is the number of KAs in school i, A is the total number KAs, and k_i represents the total kindergarten enrollment in school i. The maximum value for this index is the proportion of KXs in the population, and the index can be interpreted as the average school PBE rate for KAs. A higher exposure index indicates that KAs are more likely to encounter KXs at school. While KAs are for the most part vaccinated (some may have medical exemptions or be awaiting a scheduled immunization), they are still at risk for contracting a vaccine-preventable disease like measles given that vaccines are not 100% effective.

We conduct these analyses for the state of California for 2008-2010 to evaluate trends over time. We also plan to examine patterns by county for 2010.

PRELIMINARY RESULTS

State-level results for 2008-2010 are shown in Table 1. The PBE rate, as reported elsewhere by the CDPH, increased from 1.9% to 2.3%, a 23% increase. This increase reflects an additional 2,300 students entering school with exemptions in Fall 2010 compared to Fall 2008. The distribution of kindergarteners across schools has shifted away from schools with no PBEs and towards schools with higher PBE rates. In 2008, 3.2% of all kindergartners attended schools with PBE rates in excess of 10%. In 2010, the comparable figure was 4.3%, or almost 22,000 children. A similar shift can be seen in the proportion of KXs attending schools with high PBE rates, from 38% in 2008 to 41% in 2010. As of 2010, almost 5,000 kindergarteners with a PBE attended schools with PBE rates greater than 10%. While the overall kindergarten cohort was larger in 2010 (relative to 2008) by 8,837, 14% of that increase was KXs attending schools with high PBE rates.

These results point to an increase in the number and prevalence of PBEs, and an increase in the proportion of Ks and KXs attending schools with high PBE rates. The exposure and isolation indices provide additional insight into the clustering or concentration of PBEs within schools, and the exposure to PBEs of the average KX and KA. The exposure index tracks the PBE rate very closely, increasing from 1.6% to 2.0% from 2008-2010. Recall that this measures the PBE rate for the average KA – in other words, a typical adherent kindergartener in California in 2010 attended a school where the kindergarten PBE rates was 2.0%, slightly below the statewide PBE rate 2.3%. The percentage increases in the PBE rate and the exposure index are similar; had the percentage change in the exposure index been less than the PBE rate increase, this would have suggested an increased concentration of PBEs within schools over time. The isolation index increased from 14.7% to 15.6%, a smaller percentage increase than the

exposure index or PBE rate. While PBE prevalence is rising, the concentration of PBEs does not appear to be.

NEXT STEPS AND IMPLICATIONS

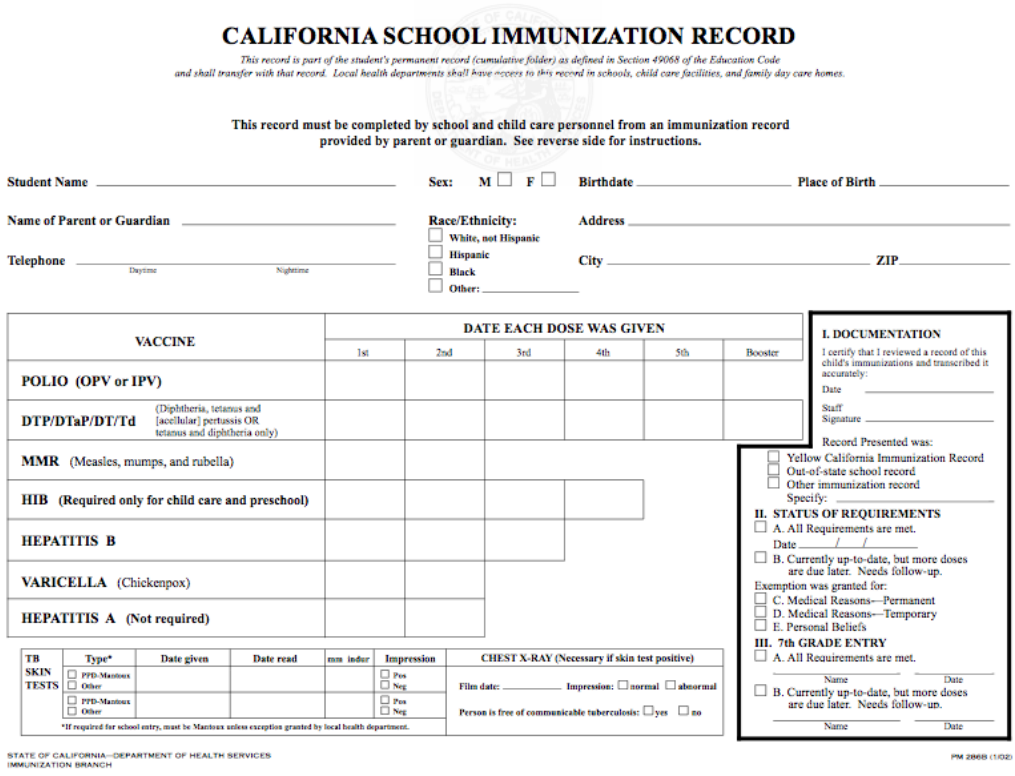
County-level exposure 2010

California's large population is distributed across 58 heterogeneous counties. In analysis still to be conducted, we will calculate county-level PBE prevalence and exposure statistics for 2010, and rank each measure from 1 (highest) to 58 (lowest). We anticipate that there will be counties (e.g., some of the smaller Sierra Nevada counties) with very high exposure and isolation indices, but relatively few KXs; as well as counties (e.g., Los Angeles counties) with a high absolute number of KXs but less exposure. This prompts an important question for public health and school health officials in California and elsewhere: Which schools or counties should be targeted for interventions to reduce the prevalence or concentration of PBEs within schools? To provide some means of prioritizing efforts with limited resources, we will present graphical depictions of county-level measures that can support CDPH efforts to reduce the risk of vaccine preventable disease outbreaks.

Are all children with PBEs unvaccinated?

This analysis assumes that high rates of PBEs are dangerous because KXs are likely to be unvaccinated. However, the CDPH recently conducted a pilot study to evaluate this hypothesis. Their results suggest that as many as 30-50% of KXs have received one or more doses of one or more vaccines. This is due both to parents securing exemptions for only one vaccination, and to school officials encouraging parents to sign the PBE waiver rather than taking a conditional acceptance (which require further follow-up by the school). Using the estimates from the CDPH analysis, we will conduct sensitivity analyses to bound our exposure measures under different scenarios of vaccination coverage for KXs.

Figure 1. California School Immunization Record.



CALIFORNIA SCHOOL IMMUNIZATION RECORD

This record is part of the student's permanent record (cumulative folder) as defined in Section 49068 of the Education Code and shall transfer with that record. Local health departments shall have access to this record in schools, child care facilities, and family day care homes.

This record must be completed by school and child care personnel from an immunization record provided by parent or guardian. See reverse side for instructions.

Student Name _____ **Sex:** M ☐ F ☐ **Birthdate** _____ **Place of Birth** _____

Name of Parent or Guardian _____ **Race/Ethnicity:** ☐ White, not Hispanic ☐ Hispanic ☐ Black ☐ Other: _____ **Address** _____

Telephone _____ (Daytime) (Nightime) **City** _____ **ZIP** _____

VACCINE	DATE EACH DOSE WAS GIVEN					
	1st	2nd	3rd	4th	5th	Booster
POLIO (OPV or IPV)						
DTP/DTaP/DT/Td (Diphtheria, tetanus and [acellular] pertussis OR tetanus and diphtheria only)						
MMR (Measles, mumps, and rubella)						
HIB (Required only for child care and preschool)						
HEPATITIS B						
VARICELLA (Chickenpox)						
HEPATITIS A (Not required)						

TB SKIN TESTS	Type*	Date given	Date read	mm indur	Impression
	☐ PPD-Mantoux ☐ Other				☐ Pos ☐ Neg
	☐ PPD-Mantoux ☐ Other				☐ Pos ☐ Neg

*If required for school entry, must be Mantoux unless exception granted by local health department.

CHEST X-RAY (Necessary if skin test positive)

Film date: _____ Impression: ☐ normal ☐ abnormal

Person is free of communicable tuberculosis: ☐ yes ☐ no

I. DOCUMENTATION

I certify that I reviewed a record of this child's immunizations and transcribed it accurately:

Date _____

Staff Signature _____

Record Presented was:

☐ Yellow California Immunization Record
☐ Out-of-state school record
☐ Other immunization record
Specify: _____

II. STATUS OF REQUIREMENTS

☐ A. All Requirements are met.
Date ___/___/___

☐ B. Currently up-to-date, but more doses are due later. Needs follow-up.

Exemption was granted for:

☐ C. Medical Reasons—Permanent
☐ D. Medical Reasons—Temporary
☐ E. Personal Beliefs

III. 7th GRADE ENTRY

☐ A. All Requirements are met.
Name _____ Date _____

☐ B. Currently up-to-date, but more doses are due later. Needs follow-up.
Name _____ Date _____

STATE OF CALIFORNIA—DEPARTMENT OF HEALTH SERVICES
IMMUNIZATION BRANCH

PM 286B (1/02)

INSTRUCTIONS FOR SCHOOL OR CHILD CARE STAFF

1. Complete child's name and address information section, or ask parent or guardian to complete this section only. (This form is not to be sent home or given to parents to complete.)
2. School or child care personnel then fill in date (month/day/year) of each immunization the student has received from the Immunization Record presented by the parent or guardian. (If the date consists only of month and year for some doses, fill in month/xx/year; however, if either measles, rubella or mumps (or MMR) was received in the month of the first birthday, month/day/year is required.)
3. Determine if immunization requirements have been met, using the California "Immunization Requirements for Grades K–12," or "Immunization Requirements for Child Care," (available from Immunization Coordinators in local health departments), or other requirements guide.
4. Complete the Documentation and Status of Requirements box.
   A. Fill in date and your signature as the staff member who reviewed and transcribed the immunization record presented by the parent or guardian. Check which type of record was presented.
   B. If the child has met all immunization requirements, check box A and write in date.
   C. If the child has not met all requirements, check box B. Child can be admitted only if up-to-date, e.g., no immunizations due currently. The child must be followed up as indicated in the "Guide to Immunization Requirements."
   D. If a child is to be exempted for medical reasons, a doctor's written statement is required; the statement must include which immunization(s) is to be exempted and the specific nature and probable duration of the medical condition. If the medical exemption is permanent, the requirement for the designated immunization(s) is met: check box A and box C.* If the medical exemption is temporary, check box B and box D; this child must be followed up.*
   E. If a child is to be exempted for reasons of personal beliefs, the parent or guardian must sign and date the affidavit below. No other parents should sign this affidavit. All requirements are met; check box A and box E.*

PERSONAL BELIEFS AFFIDAVIT TO BE SIGNED BY PARENT OR GUARDIAN—IMMUNIZATION

I hereby request exemption of the child, named on the front, from the immunization requirements for school/child care entry because all or some immunizations are contrary to my beliefs. I understand that in case of an outbreak of any one of these diseases, the child may be temporarily excluded from attending for his/her protection.

CREENCIAS PERSONALES: ESTA DECLARACIÓN JURADA DEBE SER FIRMADA POR EL PADRE O LA MADRE O EL GUARDIÁN

Solicito por la presente la dispensa de mi hijo, nombrado en el reverso, de los requisitos para vacunas de la entrada a la escuela/guardería ya que algunas o todas de las vacunas son opuestas a mis creencias. Comprendo que en caso de un brote en la communidad de alguna de estas enfermedades, mi hijo puede ser excluido temporalmente de la escuela/guardería por su propia protección.

Signature (Firma) _____ Date (Fecha) _____

Applicable only in those jurisdictions where the Tuberculosis Assessment is required for school entry

Personal Beliefs Affidavit to be Signed by Parent or Guardian—Tuberculosis

I hereby request exemption of the child named on the front from the tuberculosis assessment requirement for school/child care center entry because this procedure(s) is contrary to my beliefs. I understand that should there be cause to believe that my child is infected with active tuberculosis or should there be a tuberculosis outbreak, my child may be temporarily excluded from school.

Creencias Personales: Declaración Jurada Debe ser Firmada por el Padre o la Madre o el Guardián

Solicito por la presente la dispensa de mi hijo, nombrado en el reverso, de los requisitos para la evaluación de la tuberculosis (tisis) de la entrada a la escuela ya que esta evaluación es opuesta a mis creencias. Comprendo que si hay razón para sospechar que mi hijo sufra de la tuberculosis activa o si hay un brote de la tuberculosis, mi hijo puede ser excluido de la escuela.

Signature (Firma) _____ Date (Fecha) _____

* Names of all children who are exempt should be maintained on an exempt roster for immediate identification in case of disease outbreak in the community.

Table 1: Personal belief exemptions (PBEs) from mandated school-entry vaccinations and exposure to PBEs, California kindergarteners 2008-2010.

	Fall 2008	Fall 2009	Fall 2010	Δ 2008-2010	% Δ 2008-2010
Schools with >10 kindergarteners (N)	7,173	7,170	7,161	-12	-0.2%
Kindergarteners (N)	496,027	502,039	504,864	8,837	1.8%
Kindergarteners with PBEs (N)	9,201	9,914	11,502	2,301	25.0%
PBE rate (%)	1.9%	2.0%	2.3%	0.4%	22.8%
Distribution of kindergarteners (N) by school PBE rate					
0%	270,951	265,281	251,471	-19,480	-7.2%
0.1-9.9%	208,992	220,078	231,556	22,564	10.8%
≥10%	16,084	16,680	21,837	5,753	35.8%
Distribution of kindergarteners (%) by school PBE rate					
0%	54.6%	52.8%	49.8%	-4.8%	-8.8%
0.1-9.9%	42.1%	43.8%	45.9%	3.7%	8.9%
≥10%	3.2%	3.3%	4.3%	1.1%	33.4%
Distribution of kindergarteners (N) with PBEs by school PBE rate					
0%	--	--	--	--	--
0.1-9.9%	5,739	6,256	6,815	1,076	18.7%
≥10%	3,462	3,658	4,687	1,225	35.4%
Distribution of kindergarteners with PBEs (%) by school PBE rate					
0%	--	--	--	--	--
0.1-9.9%	62.4%	63.1%	59.3%	-3.1%	-5.0%
≥10%	37.6%	36.9%	40.7%	3.1%	8.3%
Exposure index: Average % PBE for average non-PBE student	1.6%	1.7%	2.0%	0.9%	6.1%
Isolation index: Average % PBE for average PBE student	14.7%	14.6%	15.6%	0.4%	22.5%