POPULATION HEALTH DIVISION
SAN FRANCISCO DEPARTMENT OF PUBLIC HEALTH
DISEASE PREVENTION & CONTROL

EXPANDED KINDERGARTEN RETROSPECTIVE SURVEY 2015

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Executive Summary

BACKGROUND

The Expanded Kindergarten Retrospective Survey (EKRS) is conducted approximately every three years by the San Francisco Department of Public Health (SFDPH) to retrospectively assess immunization completeness at key benchmark ages, for kindergarten children registered at public and private schools in San Francisco. The prior survey was conducted in 2011 to assess children who entered kindergarten in the fall of 2010. This survey was conducted 4 years later in 2015, to assess children who entered kindergarten (K) or transitional kindergarten (TK) in the fall of 2014.

METHODS

A 25% random sample of all 149 K/TK schools in San Francisco (SF) yielded a study sample of 19 public and 19 private K/TK schools with a total analyzable sample of 1,703 students. Data were collected from California School Immunization Records (blue cards) and school records during visits to study schools, and supplemented by accessing the California Immunization Registry (CAIR) database. Demographic data included birthdate, sex, race, ethnicity, and place of birth. Zip code was used to estimate median household income. Immunization data included the date of administration of DTP, Polio, MMR, Hepatitis B, Varicella, and Hib vaccines.

Data were analyzed for whether children were up-to-date (UTD) with the recommended childhood immunizations (individual vaccines and groups of vaccines) at age 24 months. A multivariate model was developed to examine the effect of race/ethnicity, place of birth, school type, and estimated household income on immunization completeness at age 24 months. Lastly, the results were compared to Healthy People 2020 Goals.[1]

RESULTS

Demographic characteristics of the 2015 EKRS samples of children are shown in **Table 1.** The table also allows for comparison with the 2011, 2008, 2005, and 2002 EKRS samples. Note that since random sampling was by school and not by child, the demographics of the EKRS sample may not accurately represent the population demographics of TK/K students in SF, but should approximate it. Similarly, year-to-year changes in the sample demographics may not accurately represent changes in SF population demographics over time.

In 2015, the sample consisted of 28% Asian, 26% White, 21% Hispanic, and 7% Black children, while 6% listed another race and for 12% the race/ethnicity was unknown. Foreign-born children were 5% of the sample, while for 20% the place of birth was unknown. Most children in the sample attended public school (69%).

Only 58 students (3%) were exempt from vaccinations (**Table 2**). Nearly all exemptions were personal beliefs exemption (PBE). Among those with exemptions, while most children (71%) had received at

[1] https://www.healthypeople.gov/2020/topics-objectives/topic/immunization-and-infectious-diseases/objectives

least one recommended vaccine, relatively few (29%) were UTD with a complete vaccine series at 24 months of age.

At 24 months of age, 85.9% of children were UTD for DTP vaccine, 93.5% were UTD for polio vaccine, 89.4% were UTD for MMR vaccine, 86.6% were UTD for hepatitis B vaccine, and 77.5% were UTD for varicella vaccine (**Table 3**). At 48 months of age, 93.4% of children were UTD for DTP vaccine, 96.2% were UTD for polio vaccine, 94.9% were UTD for MMR vaccine, 91.3% were UTD for hepatitis B vaccine, and 84.3% were UTD for varicella vaccine (**Table 4**). Tables 3 and 4 also show for each vaccine type the proportion of children who were UTD according to Race/Ethnicity, Sex, Place of Birth, School Type, and Income Group.

For the 4:3:1 vaccination series[2] (**Table 5):**

- Overall at 24 months of age 79.3% of children were UTD
- There were no statistically significant differences in the proportion that were UTD when analyzed by Race/Ethnicity, Sex, School Type, or Income Group.
- Foreign Born children were significantly less likely to be UTD compared with children born in San Francisco (42.2% vs. 82.5%, OR = 0.15, p<.0001).

The proportion of children UTD for the 4:3:1 series improved with age (**Table 6**), suggesting that the cohort of children studied in 2015 continued to catch up as they grew older. Fully 90.0% were UTD for the 4:3:1 series by the time they reached age 48 months. Table 6 also shows the proportion of these children who were UTD for the 4:3:1 series at various age points according to Race/Ethnicity, Sex, Place of Birth, School Type, and Income Group. Similar findings were obtained for the 4:3:1:-:3 series[3] and the 4:3:1:-:3:1 series[4] (**Table 8**).

Looking back at previous San Francisco EKRS cohorts from 2002 through 2015 (**Table 7**), the proportion of children UTD for the 4:3:1 series at age 24 months has remained relatively constant at about 79%.

Table 9 shows results of multivariate analysis of factors associated with UTD status at 24 months.

For the 4:3:1:-:3 vaccination series:

- Hispanic and Chinese Race/Ethnicity were associated with greater likelihood of being UTD compared to White Race/Ethnicity;
- Foreign Birth was associated with lower likelihood of being UTD compared to San Francisco birth; and
- Neither School Type nor Income Group was predictive of UTD status.

[2] The 4:3:1 series = 4+ doses of DTaP, 3+ doses of Polio, and 1+ doses of MMR vaccine

[3] The 4:3:1:-:3 series = 4+ doses of DTaP, 3+ doses of Polio, 1+ doses of MMR, and 3+ doses of Hepatitis B vaccine

[4] The 4:3:1:-:3:1 series = 4+ doses of DTaP, 3+ doses of Polio, 1+ doses of MMR, 3+ doses of Hepatitis B, and 1+ doses of varicella vaccine

For the 4:3:1:-:3:1 vaccination series:

- Foreign Birth was associated with lower likelihood of being UTD compared to San Francisco birth;
- Public School Type was associated with lower likelihood of being UTD compared to Private School Type; and
- Race/Ethnicity was not predictive of UTD status.

By age 36 months, the 2015 EKRS cohort of San Francisco children met the Healthy People 2020 Targets at age 19-35 months for DTaP, MMR, and Polio vaccine, but did not quite meet the immunization targets for Hepatitis B and Varicella vaccine (**Table 10**). By age 48 months, the 2015 EKRS cohort of San Francisco children had already met the Healthy People 2020 Target at age 60 months (Kindergarten entry) for Polio vaccine, and was close to meeting the immunization targets for DTaP, MMR, and Hepatitis B vaccine.

Methods

Sample

A cluster sampling methodology (sampling by school rather than by child) was chosen, because sampling schools with kindergartens or transitional kindergartens (TKs) to retrospectively assess immunizations among children aged 24 months was the most economical method of obtaining a sample. A random 25% sample of all San Francisco schools that provide registered kindergarten or transitional kindergarten education (n=149) was drawn by the California Department of Public Health (CDPH) Immunization Branch. The 2014-2015 School Year was the first year that transitional kindergarten was offered, in accordance with the Kindergarten Readiness Act of 2010. The program bridges preschool and kindergarten with a modified curriculum and is generally available to children who turn 5 years old between September 1st and December 2nd [5], while traditional kindergarten accepts children who turn 5 before September 1st. Transitional kindergarteners are subject to the same immunization requirements as kindergarteners. Sampling was performed using a modified syntax program for a commercially available statistical software product (SAS Inc., Cary, NC), and carried out by CDPH. The final 2015 sample selected by CDPH consisted of 19 public schools and 19 private schools. These represent 26% (19/73) of public kindergartens/TKs and 25% (19/76) of private kindergartens/TKs in San Francisco. The ratio of private and public schools is similar to the 2011, 2008, 2005 and 2002 EKRS samples. Every child in kindergarten/TK at the sampled school was included in the sample.

The initial sample consisted of 1716 students. After cleaning the data, 2 were removed from the sample because they were duplicate entries, and 11 were removed because the California School Immunization Record (i.e. blue card) was incomplete (i.e., name or all immunization information was missing). The final sample contained 1703 students.

Data Collection

Data were collected by the Program Coordinator (LA) and a Research Assistant (JL), who traveled to each school to review immunization records in person, photocopy them while at the school, and bring the copies back to SFDPH for data entry. Because ethnicity and place of birth information were sometimes not present on the blue card, information from the child's cumulative education files were reviewed and documented onto chart abstraction forms. Data were entered into a locally developed Microsoft Access database at SFDPH. During the data cleaning process, if discrepancies were observed in the immunization records (e.g. suspiciously early vaccination dates, record marked as "requirements met" when they were in fact missing required doses, missing sex or DOB) schools were re-contacted or the child's records were reviewed in the California Automated Immunization Registry (CAIR). The data were analyzed using SAS version 9.3.

[5] A school district or charter school may admit a child to a TK program who will have his or her fifth birthday after December 2 but during that same school year (http://www.cde.ca.gov/ci/gs/em/kinderfaq.asp)

Data Definitions

When month and year of vaccination but not day of vaccination were known, the 15th of the month was used. If the 15th of the month was before the date of birth, the date of birth was used.

Race/ethnicity data were defined as in the previous EKRS studies in order to maintain backward compatibility for the purpose of comparison.

Race/ethnicity was simplified into seven categories for analysis: White, Hispanic, Black, Chinese, Other Asian/Pacific Islander, Other, and Unknown. Race/ethnicity was collected from the blue card and, if available, from the student's cumulative education files. For this analysis, if race/ethnicity was missing from a student's blue card, the race/ethnicity in the cumulative education files was used, if available. Race/ethnicity categories were mapped from their original database values according to the scheme in the table below. There were 143 (8.4%) children classified as multiethnic on their blue cards or cumulative records. Multiethnic children marked as having Hispanic or Latino ethnicity were classified as Hispanic, regardless of other "race" categories listed for the child. For example, a child designated as Hispanic and Black would be reclassified as Hispanic. Multiethnic students who were not identified as having any Hispanic or Latino ethnicity were reclassified as the single ethnicity least represented in the San Francisco general population, according to the 2013 American Community Survey summaries. For example, a child designated as both White and Chinese was classified as Chinese because the proportion of Chinese residents in San Francisco is less than the proportion of White residents.

Race/Ethnicity Mapping Scheme

Original California School Immunization Record	***Original KRS Database Value Options***	***Categories Used for Analysis***
White, not Hispanic	White, Not Hispanic	=White
Hispanic	Hispanic/Latino	=Hispanic
Black	African American/Black	=Black
Other (specified)	Chinese Asian (includes Taiwanese)	=Chinese
Other (specified)	Filipino Asian, Pacific Islander*, South Asian**, South East Asian***, Other Asian****, Asian Not Specified	=Other Asian/Pacific Islander
Other (specified)	American Indian/Alaskan Native, Middle Eastern/Arabic, Multi (not specified)	=Other
Other (specified)	Not Stated	=Unknown

* Pacific Islander includes Native Hawaii, Guam, Fiji, Polynesia, Tonga, and Samoa.

**South Asian includes India, Pakistan, Nepal, Sri Lanka, Bangladesh, and Afghanistan

***South East Asian includes Vietnam, Cambodia, Thailand, Malaysia, Laos, Indonesia, Singapore, and Myanmar/Burma.

****Other Asian includes Korea, Japan, and any other Asian country not listed above.

As median household incomes were not available from school data, they were derived from the 2013 American Community Survey Summaries based on a student's home zip code. Median household

income was categorized into five income groups for analysis: <$40,000; $40,000-69,999; $70,000-99,999; >=$100,000; and Unknown (zip code not provided).

The following vaccinations were assessed:

- diphtheria, tetanus and pertussis (DTP, DTaP, DT, Td);
- polio (OPV, IPV);
- measles, mumps and rubella (MMR);
- hepatitis B (HepB); and
- Varicella (Var)

Hepatitis A, pneumococcal conjugate, and rotavirus vaccines are not required for TK/K entry and were not assessed. *Haemophilus influenzae* type b (Hib) is required only for entry to childcare or pre-school. Elementary schools are not required to fill out Hib information, and some schools entered the Hib information while most did not. Due to this significant variability in school practice and the high rate of missing Hib information, Hib was not assessed, and vaccination series including Hib [series 4:3:1:3:3 (DTP4 + Polio3 + MMR1 + Hib3 + HepB3) and series 4:3:1:3:3:1 (DTP4 + Polio3 + MMR1 + Hib3 + HepB3 + Var1) were also not assessed.

Up-to-date (UTD) status for MMR or varicella vaccinations was assessed only at ages 15 months, 18 months, 24 months, 27.5 months, 36 months, and 48 months. This was because the recommended age for the first dose for MMR- and varicella-containing vaccination series occurs after 12 months.
UTD status for all other individual vaccines was assessed at 2 months, 4 months, 6 months, 12 months, 15 months, 18 months, 24 months, 27.5 months, 36 months, and 48 months.

For the purpose of calculating UTD status, each month was counted as having 30.25 days. Any twelve month period was equal to 365 days. Benchmark ages for primary series vaccines recommended at ages up to 18 months included a grace period comprising the next full month following the recommendation, whereas for the catch-up period of ages 24 months or later, the benchmarks were set at the end of the benchmark month. For example:

> A child was considered UTD for a particular vaccination schedule at 6 months of age if the vaccine was given at age 212 days or before (6 months x 30.25 days/month = 185.5 days, plus another 30.5 days = 212).
>
> A child was considered UTD for a particular vaccination schedule at 24 months of age if the vaccine was given at age 730 days or before (2 years x 365 days/year).

Vaccinations required for UTD status for vaccine series at these benchmark ages are implicit in their naming (e.g. UTD for series 4:3:1 required that the child had received DTP4, Polio3, and MMR1 by the given age). Based on the 2015 recommended schedule for childhood vaccinations[6] children were considered UTD for each vaccination according to the following scheme:

[6] http://www.cdc.gov/vaccines/schedules/downloads/past/2015-child.pdf

Benchmark Ages for Vaccines

Benchmark Age	*Vaccination Required to Be UTD*				
	DTP	*Polio*	*MMR*	*HepB*	*Var*
2 months ≤ 91 days	DTP1	Polio1	n/a	HepB1	n/a
4 months ≤ 152 days	DTP2	Polio2	n/a	HepB2	n/a
6 months ≤ 212 days	DTP3	Polio3	n/a	HepB3	n/a
12 months ≤ 396 days	DTP3	Polio3	n/a	HepB3	n/a
15 months ≤ 486 days	DTP4	Polio3	MMR1	HepB3	Var1
18 months ≤ 577 days	DTP4	Polio3	MMR1	HepB3	Var1
24 months ≤ 730 days	DTP4	Polio3	MMR1	HepB3	Var1
27.5 months ≤ 836 days	DTP4	Polio3	MMR1	HepB3	Var1
36 months ≤ 1095 days	DTP4	Polio3	MMR1	HepB3	Var1
48 months ≤ 1460 days	DTP4	Polio3	MMR1	HepB3	Var1

n/a = not applicable; MMR1 and Var1 not recommended before 12 months of age.

The first MMR was considered valid at a particular benchmark age if it was administered on or after 361 days of age (a 4-day grace period from the first birthday is allowed for the first MMR) and on or before the benchmark age. If the first MMR was administered at or prior to 360 days of age, then that dose was considered invalid, and the date of the second MMR (if available) was used as the date of the first valid MMR. If the first MMR was administered early and a valid second MMR was not given, then the child was not considered to have had a valid MMR.

For determining the age at which an invalid first MMR dose was administered, the following ages in days were used:

1 month ≤ 31 days	7 months ≤ 212 days
2 months ≤ 61 days	8 months ≤ 242 days
3 months ≤ 91 days	9 months ≤ 273 days
4 months ≤ 121 days	10 months ≤ 303 days
5 months ≤ 152 days	11 months ≤ 333 days
6 months ≤ 182 days	12 months ≤ 360 days

Data Validation

At the time of data entry, a Research Assistant (JL) reviewed the immunization records for logical errors. Additionally, dates for serial immunization schedules were later validated during data cleaning for consistency to ensure each shot in a scheduled vaccine series was administered sequentially (e.g., the date of the second DTP administration was before that of the third DTP; the date of the third DTP administration was before that of the fourth DTP). When necessary, a photocopy of the child's blue card or the child's CAIR record was consulted to correct data entry errors. Transcription errors made by school clerical staff could sometimes be corrected by comparison to other vaccination dates for the same child.

Outcomes of Interest

The primary outcome of interest was whether children were up-to-date for recommended childhood immunizations at 24 months of age. The proportion of children UTD at 24 months of age and at other critical age benchmarks for individual vaccinations and for three vaccine series were calculated; the 95% confidence limits were also calculated using a SAS macro for exact confidence limits[7]. The primary outcomes included:

- UTD with the 4:3:1 series (DTP4 + Polio3 + MMR1);
- UTD with the 4:3:1:-:3 series (DTP4 + Polio3 + MMR1 + HepB3);
- UTD with the 4:3:1:-:3:1 series (DTP4 + Polio3 + MMR1 + HepB3 + Var1); and
- UTD with DTP, Polio, MMR, HepB, and Varicella individually.

For secondary outcomes of interest, UTD status for individual vaccinations was assessed at 2, 4, 6, 12, 15, and 18 months of age. UTD status for the 4:3:1, 4:3:1:-:3, and 4:3:1:-:3:1 series was evaluated at 15 and 18 months of age. Late UTD (catch-up) status for all individual vaccinations and series was assessed at 27.5, 36, and 48 months of age.

Vaccine Series

Series Name	Meaning
4:3:1	4 DTP, 3 Polio, 1 MMR: Four or more doses of DTaP, three or more doses of Polio, and one or more doses of MMR
4:3:1:-:3	4 DTP, 3 Polio, 1 MMR, 3 HepB: Four or more doses of DTaP, three or more doses of Polio, one or more doses of MMR, and three or more doses of HepB.
4:3:1:-:3:1	4 DTP, 3 Polio, 1 MMR, 3 HepB, 1 Varicella: Four or more doses of DTaP, three or more doses of Polio, one or more doses of MMR, three or more doses of HepB, and one or more doses of varicella

School records also provided sex, ethnicity, place of birth and zip code (used to derive household income), as well as whether the child had a temporary or permanent exemption from vaccination. The proportion UTD for all vaccinations and series was analyzed by these demographics, as well as by school type (public or private). Univariate and multivariate regression was performed in SAS to elucidate the relationship between being UTD for the 4:3:1 vaccination series at 24 months of age (the dependent variable) and sex, ethnicity, place of birth, median household income group, and type of school (the independent variables).

[7] Leslie Day (1992), "Simple SAS macros for the calculation of exact binomial and Poisson confidence limits." Comput Biol Med, 22(5):351-361

Caveats to the Data
Results from the 2015 EKRS should be interpreted with the following caveats.

Potential Sampling Bias
While a random sample of schools was obtained, this is not a random sample of students.

Place of birth data was unknown or missing for 332 (19.5%) of the sampled population. It is unclear how this large amount of missing information may have affected the UTD comparison based on place of birth. We were unable to adjust for sampling bias by birthplace; population-based data for birthplace is not available from the U.S. census.

Race/ethnicity was unknown or missing for 200 (11.7%) students. Because there is significant variability in vaccination rates between ethnicity groups, basing conclusions on a sample not entirely representative of the ethnicity distributions of San Francisco kindergarteners and transitional kindergarteners could result in a biased estimate of vaccination coverage for the overall population.

Median Household Income based on Zip Code
Zip code can cover a large geographic area with a wide range of variability in the incomes of the households within it. Using a student's home zip code may not accurately reflect household income.

Exemptions
The proportion of sampled children with exemptions to vaccination due to medical contraindications or parental personal beliefs was 3.4% (58), which is similar to 2011's proportion of 3.3% (59). Exempted children are counted in the denominator when the proportion UTD for any vaccination or series is calculated. Consequently, an increase in the frequency of exemptions from vaccination influences the proportion UTD downward.

Results

List of tables

Table 1: Sampled population characteristics across EKRS studies, San Francisco, EKRS 2002-2015

	2015 N (%)	2011 N (%)	2008 N (%)	2005 N (%)	2002 N (%)
Overall	1703	1766	1564	1466	1642
Race/Ethnicity					
Asian	473 (27.8)	554 (31.4)	472 (30.2)	560 (38.2)	658 (40.1)
Black	124 (7.3)	121 (6.9)	142 (9.1)	151 (10.3)	155 (9.4)
Hispanic	359 (21.1)	318 (18.0)	327 (20.9)	292 (19.9)	311 (18.9)
White	447 (26.3)	294 (16.6)	440 (28.1)	311 (21.2)	283 (17.2)
Other	100 (5.9)	114 (6.5)	115 (7.4)	63 (4.3)	102 (6.2)
Unknown	200 (11.7)	365 (20.7)	68 (4.4)	89 (6.1)	133 (8.1)
Sex					
Male	807 (47.4)	832 (47.1)	766 (49.0)	696 (47.5)	802 (48.8)
Female	896 (52.6)	929 (52.6)	792 (50.6)	765 (52.2)	840 (51.2)
Unknown	0	5 (0.3)	6 (0.4)	5 (0.3)	0
Place of Birth					
San Francisco	930 (54.6)	878 (49.7)	998 (63.8)	756 (51.6)	1146 (69.8)
California	283 (16.6)	138 (7.8)	117 (7.5)	219 (14.9)	148 (9.0)
United States	68 (4.0)	276 (15.6)	105 (6.7)	182 (12.4)	37 (2.2)
Foreign Born	90 (5.3)	98 (5.5)	137 (8.8)	126 (8.6)	154 (9.4)
Unknown	332 (19.5)	376 (21.3)	207 (13.2)	183 (12.5)	157 (9.6)
School Type					
Public	1177 (69.1)	1280 (72.5)	1025 (65.5)	998 (68.1)	1,070 (65.2)
Private	526 (30.9)	486 (27.5)	539 (34.5)	468 (31.9)	572 (34.8)
Exemptions					
None	1645 (96.6)	1707 (96.7)	1545 (98.8)	1443 (98.4)	1633 (99.5)
Exempted	58 (3.4)	59 (3.3)	19 (1.2)	23 (1.6)	9 (0.5)
Income Group by Zip Code					
<$40000	42 (2.5)				
$40000-69999	456 (26.8)				
$70000-99999	826 (48.5)				
>=$100000	205 (12.0)				
Unknown	174 (10.2)				

Table 2: Demographics of students exempt from vaccinations (N=58), San Francisco, EKRS 2015

	N (%)
Type of Exemption	
Medical Permanent	1 (1.7)
Medical Temporary	2 (3.5)
Personal Belief	55 (94.8)
Race/Ethnicity	
White	24 (41.4)
Hispanic	7 (12.1)
Black	1 (1.7)
Chinese	4 (6.9)
Other Asian/PI	2 (3.5)
Other	3 (5.2)
Unknown	17 (29.3)
Sex	
Male	23 (39.7)
Female	35 (60.3)
Place of Birth	
San Francisco	25 (43.1)
California	6 (10.3)
United States	2 (3.5)
Foreign Born	6 (10.3)
Unknown	19 (32.8)
School Type	
Public	24 (41.4)
Private	34 (58.6)
Income Group by Zip Code	
<$40000	1 (1.7)
$40000-69999	9 (15.5)
$70000-99999	29 (50.0)
>=$100000	13 (22.4)
Unknown	6 (10.3)
Vaccinations	
No vaccinations	17 (29.3)
UTD for at least 1 series at 24 months	17 (29.3)

Table 3: The proportion of children UTD for specific vaccine types at 24 months of age, San Francisco, EKRS 2015

	DTP % (95% CI)	Polio % (95% CI)	MMR % (95% CI)	Hepatitis B % (95% CI)	Varicella % (95% CI)
Overall	85.9 (81.6 -90.4)	93.5 (89.0 – 98.2)	89.4 (84.9 – 94.0)	86.6 (82.2 – 91.1)	77.5 (73.3 – 81.7)
Race/Ethnicity					
White	87.2 (78.8 – 96.4)	91.7 (83.1 – 100.0)	87.5 (79.0 – 96.6)	79.9 (71.8 – 88.6)	74.5 (66.7 – 82.9)
Hispanic	87.5 (78.1 – 97.7)	95.5 (85.7 – 100.0)	92.8 (83.1 – 100.0)	91.9 (82.3 – 100.0)	73.8 (65.2 – 83.3)
Black	80.6 (65.6 – 98.1)	92.7 (76.6 – 100.0)	90.3 (74.4 – 100.0)	90.3 (74.4 – 100.0)	83.9 (68.5 – 100.0)
Chinese	90.2 (78.0 – 100.0)	98.1 (85.3 – 100.0)	90.7 (78.4 – 100.0)	95.3 (82.7 – 100.0)	85.6 (73.7 – 98.9)
Other Asian/PI	84.1 (73.3 – 96.1)	94.2 (82.7 – 100.0)	90.7 (79.4 – 100.0)	90.3 (79.1 – 100.0)	79.8 (69.3 – 91.5)
Other	85.0 (67.9 – 100.0)	96.0 (77.8 – 100.0)	89.0 (71.5 – 100.0)	82.0 (65.2 – 100.0)	79.0 (62.5 – 98.5)
Unknown	81.5 (69.5 – 95.0)	87.5 (75.0 – 100.0)	84.0 (71.8 – 97.7)	77.5 (65.8 – 90.7)	74.0 (62.6 – 86.9)
Sex					
Male	86.2 (80.0 – 92.9)	93.1 (86.5 – 100.0)	89.0 (82.6 – 95.7)	87.5 (81.1 – 94.2)	76.5 (70.5 – 82.7)
Female	85.6 (79.7 – 91.9)	94.0 (87.7 – 100.0)	89.7 (83.6 – 96.2)	85.7 (79.8 – 92.0)	78.3 (72.7 – 84.4)
Place of Birth					
San Francisco	88.5 (82.6 – 94.8)	94.4 (88.3 – 100.0)	91.8 (85.8 – 98.2)	88.9 (83.0 – 95.2)	81.0 (75.3 – 87.0)
California	86.9 (76.4 – 98.5)	95.4 (84.4 – 100.0)	90.8 (80.0 -100.0)	90.8 (80.0 – 100.0)	73.1 (63.5 – 83.8)
United States	83.8 (63.5 – 100.0)	91.2 (69.9 – 100.0)	86.8 (66.0 – 100.0)	86.8 (66.0 – 100.0)	75.0 (55.8 – 98.6)
Foreign Born	56.7 (42.2 – 74.5)	86.7 (68.5 – 100.0)	64.4 (48.9 – 83.3)	72.2 (55.7 – 92.1)	44.4 (31.8 – 60.5)
Unknown	86.1 (76.4 – 96.7)	91.9 (81.8 – 100.0)	88.6 (78.7 – 99.3)	80.1 (70.8 – 90.4)	80.7 (71.3 – 91.0)
School Type					
Public	84.9 (79.7 – 90.3)	93.7 (88.3 – 99.4)	89.0 (83.7 – 94.6)	88.9 (83.6 – 94.4)	74.3 (69.4 – 79.3)
Private	88.2 (80.4 – 96.6)	93.2 (85.1 – 100.0)	90.1 (82.2 – 98.6)	81.4 (73.8 – 89.5)	84.6 (76.9 – 92.8)
Income Group by Zip Code					
<$40000	81.0 (56.1 – 100.0)	95.2 (68.0 – 100.0)	90.5 (64.0 – 100.0)	88.1 (62.0 – 100.0)	81.0 (56.1 – 100.0)
$40000-69999	81.6 (73.5 – 90.3)	95.0 (86.2 – 100.0)	89.7 (81.2 – 98.8)	91.2 (82.7 – 100.0)	78.7 (70.8 – 87.3)
$70000-99999	87.9 (81.6 – 94.5)	94.2 (87.7 – 100.0)	89.7 (83.4 – 96.4)	86.0 (79.7 – 92.5)	75.9 (70.1 – 82.1)
>=$100000	86.3 (74.1 – 100.0)	90.7 (78.2 – 100.0)	89.8 (77.3 – 100.0)	83.9 (71.8 – 97.4)	82.9 (70.9 – 96.4)
Unknown	88.5 (75.1 – 100.0)	89.7 (76.1 – 100.0)	86.2 (73.0 – 100.0)	79.9 (67.2 – 94.3)	74.1 (61.9 – 88.1)

Table 4: The proportion of children UTD for specific vaccine types at 48 months of age, San Francisco, EKRS 2015

	DTP % (95% CI)	Polio % (95% CI)	MMR % (95% CI)	Hepatitis B % (95% CI)	Varicella % (95% CI)
Overall	93.4 (88.9 – 98.1)	96.2 (91.6 – 100.0)	94.9 (90.3 – 99.6)	91.3 (86.8 – 96.0)	84.3 (80.0 – 88.7)
Race/Ethnicity					
White	93.5 (84.8 – 100.0)	94.9 (86.0 – 100.0)	94.0 (85.2 – 100.0)	86.1 (77.7 – 95.2)	84.6 (76.3 – 93.5)
Hispanic	94.4 (84.6 – 100.0)	96.7 (86.8 – 100.0)	95.8 (86.0 – 100.0)	94.7 (84.9 – 100.0)	77.2 (68.3 – 86.8)
Black	94.4 (78.0 – 100.0)	97.6 (81.0 – 100.0)	94.4 (78.0 – 100.0)	94.4 (78.0 – 100.0)	91.1 (75.1 – 100.0)
Chinese	95.3 (82.7 – 100.0)	98.1 (85.3 – 100.0)	96.7 (84.0 – 100.0)	98.1 (85.3 – 100.0)	90.2 (78.0 – 100.0)
Other Asian/PI	92.6 (81.3 – 100.0)	98.1 (86.3 – 100.0)	97.3 (85.6 – 100.0)	95.7 (84.2 – 100.0)	88.4 (77.3 – 100.0)
Other	94.0 (76.0 – 100.0)	98.0 (79.6 – 100.0)	93.0 (75.1 – 100.0)	88.0 (70.6 – 100.0)	87.0 (69.7 – 100.0)
Unknown	89.5 (76.9 – 100.0)	92.0 (79.2 – 100.0)	91.5 (78.7 – 100.0)	83.5 (71.3 – 97.2)	79.0 (67.2 – 92.3)
Sex					
Male	93.6 (87.0 – 100.0)	95.8 (89.2 – 100.0)	95.2 (88.6 – 100.0)	91.6 (85.1 – 98.4)	82.8 (76.6 – 89.3)
Female	93.3 (87.1 – 99.8)	96.5 (90.2 – 100.0)	94.6 (88.4 – 100.0)	91.1 (84.9 – 97.5)	85.6 (79.7 – 91.9)
Place of Birth					
San Francisco	95.1 (88.9 – 100.0)	96.9 (90.7 – 100.0)	96.3 (90.1 – 100.0)	93.4 (87.3 – 99.9)	86.8 (80.9 – 93.0)
California	94.0 (83.0 – 100.0)	97.5 (86.4 – 100.0)	95.4 (84.4 – 100.0)	92.9 (82.0 – 100.0)	77.0 (67.1 – 88.00)
United States	91.2 (69.9 – 100.0)	94.1 (72.5 – 100.0)	95.6 (73.8 – 100.0)	92.6 (71.2 – 100.0)	80.9 (60.9 – 100.0)
Foreign Born	80.0 (62.6 – 100.0)	93.3 (74.4 – 100.0)	82.2 (64.6 – 100.0)	81.1 (63.6 – 100.0)	63.3 (48.0 – 82.1)
Unknown	92.5 (82.4 – 100.0)	96.2 (91.6 – 100.0)	93.7 (83.6 – 100.0)	86.4 (76.7 – 97.0)	89.8 (79.9 – 100.0)
Type of School					
Public	93.2 (87.8 – 98.9)	96.3 (90.8 – 100.0)	95.1 (89.6 – 100.0)	92.9 (87.5 – 98.6)	80.5 (75.5 – 85.8)
Private	93.9 (85.8 – 100.)	95.8 (87.6 – 100.0)	94.5 (86.4 – 100.0)	87.6 (79.8 – 96.0)	92.6 (84.5 – 100.0)
Income Group by Zip Code					
<$40000	92.9 (66.0 – 100.0)	97.6 (70.1 – 100.0)	95.2 (68.0 – 100.0)	92.9 (66.0 – 100.0)	88.1 (62.0 – 100.0)
$40000-69999	91.9 (83.3 – 100.0)	96.7 (87.9 – 100.0)	95.6 (86.8 – 100.0)	95.0 (86.2 – 100.0)	85.7 (77.5 – 94.7)
$70000-99999	93.8 (87.3 – 100.0)	96.6 (90.0 – 100.0)	95.0 (88.5 – 100.0)	90.6 (84.2 – 97.3)	82.7 (76.6 – 89.1)
>=$100000	93.7 (80.9 – 100.0)	94.1 (81.3 – 100.0)	94.6 (81.8 – 100.0)	89.8 (77.3 – 100.0)	87.3 (75.0 – 100.0)
Unknown	95.4 (81.4 – 100.0)	94.8 (80.9 – 100.0)	92.5 (78.8 – 100.0)	86.8 (73.5 – 100.0)	83.3 (70.3 - 98.1)

Table 5: Univariate associations between children UTD for series 4:3:1 and demographics at 24 months of age, San Francisco, EKRS 2015 [8]

	Complete 4:3:1 Series N (%, 95% CI)	Incomplete series or not UTD N (%)	OR (95% CI)	P
Overall	1,351 (79.3, 75.2 – 83.7)	352 (20.7)		
Race/Ethnicity				
White	349 (78.1, 70.1 – 86.7)	98 (21.9)	1.00	
Hispanic	298 (83.0, 73.9 – 93.0)	61 (17.0)	1.20 (0.79 – 1.82)	0.39
Black	94 (75.8, 61.3 – 92.8)	30 (24.2)	0.73 (0.53 – 1.01)	0.06
Chinese	182 (84.7, 72.8 – 97.9)	33 (15.3)	1.49 (0.89 – 2.49)	0.13
Other Asian/PI	204 (79.1, 68.6 – 90.7)	54 (20.9)	0.93 (0.64 – 1.34)	0.70
Other	80 (80.0, 63.4 – 99.6)	20 (20.0)	0.97 (0.57 – 1.65)	0.92
Unknown	144 (72.0, 60.7 – 84.8)	56 (28.0)	0.80 (0.54 – 1.18)	0.25
Sex				
Male	643 (79.7, 73.6 – 86.1)	164 (20.3)	1.00	
Female	708 (79.0, 73.3 – 85.1)	188 (21.0)	0.99 (0.76 – 1.30)	0.98
Place of Birth				
San Francisco	767 (82.5, 76.7 – 88.5)	163 (17.5)	1.00	
California	230 (81.3, 71.1 – 92.5)	53 (18.7)	0.90 (0.52 – 1.57)	0.71
United States	53 (77.9, 58.4 – 100.0)	15 (22.1)	0.79 (0.43 – 1.44)	0.44
Foreign Born	38 (42.2, 29.9 – 58.0)	52 (57.8)	**0.15 (0.09 – 0.27)**	**<0.0001**
Unknown	263 (79.2, 69.9 – 89.4)	69 (20.8)	0.91 (0.59 – 1.41)	0.67
School Type				
Public	924 (78.5, 73.5 – 83.7)	253 (21.5)	0.68 (0.46 – 1.01)	0.06
Private	427 (81.2, 73.7 – 89.3)	99 (18.8)	1.00	
Income Group by Zip Code	32 (76.2, 52.1 – 100.0)	10 (23.8)	0.74 (0.35 – 1.55)	0.42
<$40000	352 (77.2, 69.3 – 85.7)	104 (22.8)	0.74 (0.43 – 1.27)	0.27
$40000-69999	672 (81.4, 75.3 – 87.7)	154 (18.6)	1.02 (0.61 – 1.69)	0.95
$70000-99999	162 (79.0, 67.3 – 92.2)	43 (21.0)	1.00	
>=$100000	133 (76.4, 64.0 – 90.6)	41 (23.6)	0.76 (0.40 – 1.44)	0.40
Unknown				

[8] Children with exemptions were excluded from this analysis.

Table 6: The proportion of children UTD for the 4:3:1 series at 15-48 months of age, San Francisco, EKRS 2015

	15 mos % (95% CI)	18 mos % (95% CI)	24 mos % (95% CI)	27.5 mos % (95% CI)	36 mos % (95% CI)	48 mos % (95% CI)
Overall	35.1 (32.3 – 38.0)	65.4 (61.6 – 69.3)	79.3 (75.2 – 83.7)	84.4 (80.1 – 88.9)	88.0 (83.6 – 92.6)	90.0 (85.6 – 94.6)
Race/Ethnicity						
White	34.0 (28.8 – 39.9)	64.2 (57.0 – 72.1)	78.1 (70.1 – 86.7)	83.7 (75.4 – 92.6)	86.6 (78.2 – 95.6)	89.3 (80.7 – 98.5)
Hispanic	34.8 (29.0 – 41.5)	70.2 (61.8 – 79.4)	83.0 (73.9 – 93.0)	87.2 (77.8 – 97.4)	91.4 (81.7 – 100.0)	91.9 (82.3 – 100.0)
Black	28.2 (19.7 – 39.3)	58.9 (46.1 – 74.0)	75.8 (61.3 – 92.8)	81.5 (66.3 – 99.0)	85.5 (70.0 – 100.0)	90.3 (74.4 – 100.0)
Chinese	43.3 (34.9 – 53.0)	69.8 (59.0 – 81.9)	84.7 (72.8 – 97.9)	90.2 (78.0 – 100.0)	92.1 (79.7 – 100.0)	92.6 (80.1 – 100.0)
Other Asian/PI	36.8 (29.8 – 45.0)	65.9 (56.4 – 76.6)	79.1 (68.6 – 90.7)	84.1 (73.3 – 96.1)	89.1 (78.0 – 100.0)	91.1 (79.8 – 100.0)
Other	32.0 (21.9 – 45.2)	67.0 (51.9 – 85.1)	80.0 (63.4 – 99.6)	84.0 (67.0 – 100.0)	88.0 (70.6 – 100.0)	90.0 (72.4 – 100.0)
Unknown	32.5 (25.1 – 41.4)	57.0 (47.0 – 68.5)	72.0 (60.7 – 84.8)	77.0 (65.3 – 90.2)	81.0 (69.0 – 94.5)	84.0 (71.8 – 97.7)
Sex						
Male	35.4 (31.5 – 39.8)	65.4 (60.0 – 71.3)	79.7 (73.6 – 86.1)	84.4 (78.2 – 91.0)	87.9 (81.5 – 94.6)	90.3 (83.9 – 97.1)
Female	34.7 (31.0 – 38.8)	65.3 (60.1 – 70.8)	79.0 (73.3 – 85.1)	84.4 (78.5 – 90.6)	88.2 (82.1 – 94.5)	89.7 (83.6 – 96.2)
Place of Birth						
San Francisco	34.5 (30.8 – 38.5)	68.3 (63.1 – 73.8)	82.5 (76.7 – 88.5)	87.3 (81.4 – 93.5)	90.8 (84.7 – 97.1)	92.0 (86.0 – 98.4)
California	41.7 (34.5 – 49.9)	69.6 (60.2 – 80.0)	81.3 (71.1 – 92.5)	86.2 (75.7 – 97.7)	89.8 (79.1 – 100.0)	91.2 (80.4 – 100.0)
United States	38.2 (25.0 – 56.0)	58.8 (42.0 – 80.1)	77.9 (58.4 – 100.0)	80.9 (60.9 – 100.0)	86.8 (66.0 – 100.0)	88.2 (67.3 – 100.0)
Foreign Born	8.9 (3.8 – 17.5)	25.6 (16.2 – 38.3)	42.2 (29.9 – 58.0)	53.3 (39.3 – 70.7)	64.4 (48.9 – 83.3)	72.2 (55.7 – 92.1)
Unknown	37.3 (31.1 – 44.5)	65.7 (57.2 – 75.0)	79.2 (69.9 – 89.4)	83.7 (74.2 – 94.2)	85.5 (75.9 – 96.1)	88.6 (78.7 – 99.3)
Type of School						
Public	33.1 (29.8 – 36.5)	64.1 (59.7 – 68.9)	78.5 (73.5 – 83.7)	83.9 (78.7 – 89.3)	88.0 (82.7 – 93.5)	90.0 (84.6 – 95.6)
Private	39.5 (34.4 – 45.3)	68.1 (61.2 – 75.5)	81.2 (73.7 – 89.3)	85.6 (77.8 – 93.8)	88.0 (80.2 – 96.4)	90.1 (82.2 – 98.6)
Income Group by Zip						
<$40000	33.3 (18.2 – 55.9)	61.9 (40.4 – 90.7)	76.2 (52.1 – 100.0)	81.0 (56.1 – 100.0)	90.5 (64.0 – 100.0)	90.5 (64.0 – 100.0)
$40000-69999	31.4 (26.4 – 36.9)	62.7 (55.7 – 70.4)	77.2 (69.3 – 85.7)	82.7 (74.5 – 91.5)	86.8 (78.5 – 95.8)	89.3 (80.8 – 98.4)
$70000-99999	36.3 (32.3 – 40.7)	66.1 (60.7 – 71.9)	81.4 (75.3 – 87.7)	86.0 (79.7 – 92.5)	89.2 (82.9 – 95.9)	90.8 (84.4 – 97.5)
>=$100000	41.0 (32.7 – 50.7)	70.7 (59.7 – 83.2)	79.0 (67.3 – 92.2)	82.9 (70.9 – 96.4)	87.8 (75.4 – 100.0)	89.3 (76.8 – 100.0)
Unknown	32.2 (24.3 – 41.8)	63.2 (52.0 – 76.2)	76.4 (64.0 – 90.6)	83.9 (70.8 – 98.7)	85.1 (71.9 – 99.9)	89.1 (75.6 – 100.0)

Table 7: The proportion of children UTD for the 4:3:1 series at 24 months of age by year of EKRS study, San Francisco, EKRS 2002 - 2015

2015 % (95% CI)	2011 % (95% CI)	2008 % (95% CI)	2005 % (95% CI)	2002 % (95% CI)
79.3 (75.2 – 83.7)	79.3 (75.2 – 83.5)	79.3 (75.0 – 83.9)	77.4 (72.9 – 82.0)	81.5 (79.6 – 83.4)

Table 8: The proportion of children UTD for the 4:3:1:-:3 and 4:3:1:-:3:1 series at 15-48 months of age, San Francisco, EKRS 2015

	4:3:1:-:3 series % (95% CI)	4:3:1:-:3:1 series % (95% CI)
15 months of age	32.6 (29.9 – 35.4)	27.2 (24.8 – 29.8)
18 months of age	61.4 (57.7 – 65.2)	53.3 (49.8 – 56.8)
24 months of age	73.9 (69.9 – 78.1)	64.6 (60.8 – 68.5)
27.5 months of age	79.1 (74.9 – 83.4)	69.5 (65.6 – 73.6)
36 months of age	82.9 (78.6 – 87.3)	73.0 (69.0 – 77.2)
48 months of age	85.5 (81.2 – 90.0)	75.9 (71.8 – 80.2)

Table 9: Multivariate logistic regression analysis of children UTD for Series 4:3:1:-:3 and 4:3:1:-:3:1 by available demographics at 24 months of age, San Francisco, EKRS 2015 [9]

	4:3:1:-:3 series		4:3:1:-:3:1 series	
	OR (95% CI)	**P**	**OR (95% CI)**	**P**
Race/Ethnicity				
White	1.00			
Hispanic	**1.69 (1.13 – 2.51)**	**0.01**		
Black	0.86 (0.60 – 1.21)	0.38		
Chinese	**2.91 (1.80 – 4.71)**	**<0.0001**		
Other Asian/PI	1.35 (0.95 – 1.92)	0.09		
Other	1.33 (0.87 – 2.02)	0.19		
Unknown	0.92 (0.63 – 1.34)	0.65		
Place of Birth				
San Francisco	1.00		1.00	
California	0.88 (0.58 – 1.36)	0.57	0.65 (0.35 – 1.23)	0.19
United States	0.98 (0.56 – 1.71)	0.93	0.65 (0.37 – 1.16)	0.14
Foreign Born	**0.14 (0.07 – 0.27)**	**<0.0001**	**0.16 (0.08 – 0.32)**	**<0.0001**
Unknown	0.84 (0.56 – 1.27)	0.41	0.72 (0.45 – 1.15)	0.17
School Type				
Public			**0.47 (0.27 – 0.82)**	**0.007**
Private			1.00	
Income Group by Zip Code				
<$40000			1.55 (0.58 – 4.09)	0.38
$40000-69999			0.93 (0.54 – 1.60)	0.78
$70000-99999			0.74 (0.49 – 1.12)	0.15
>=$100000			1.00	
Unknown			**0.45 (0.26 – 0.78)**	**0.005**

[9] Children with exemptions were excluded from this analysis. Only significant associations from univariate analyses with the respective vaccine series (4:3:1:-3 and 4:3:1:-3:1) were included in the multivariate model.

Table 10: Comparison to Healthy People 2020 Targets, San Francisco, EKRS 2015 [10]

Healthy People 2020 Goal	San Francisco
90% of children aged 19 to 35 months received 4 or more doses of the combination of diphtheria, tetanus, and acellular pertussis antigens (DTaP)	92.2% (95% CI 87.7 – 96.9) at 36 months
90% of children aged 19 to 35 months received 3 or more doses of Hib vaccine	Not assessed
90% of children aged 19 to 35 months received at least 3 doses of the hepatitis B vaccine	89.3% (95% CI 84.9 – 93.9) at 36 months
90% of children aged 19 to 35 months received 1 dose of measles-mumps-rubella (MMR) vaccine	93.8% (95% CI 89.2 – 98.5) at 36 months
90% of children aged 19 to 35 months received at least 3 doses of polio vaccine	95.4% (95% CI 90.8 – 100.0) at 36 months
90% of children aged 19 to 35 months received at least 1 dose of the varicella vaccine	82.3% (95% CI 78.1 – 86.8) at 36 months
90% of children aged 19 to 35 months received at least 4 doses of the pneumococcal conjugate vaccine	Not assessed
85% of children aged 19 to 35 months received 2 or more doses of hepatitis A vaccine	Not assessed
85% of the birth cohort received the first dose of hepatitis B vaccine within 3 days of birth	52.6%
80% of children aged 19 to 35 months received 2 or more doses of rotavirus vaccine	Not assessed
80% of children aged 19 to 35 months received the recommended doses of DTaP, polio, MMR, Hib, hepatitis B, varicella, and PCV vaccines.	Not assessed
95% of children enrolled in kindergarten received 4 doses of DTaP vaccine	93.4% (95% CI 88.9 – 98.1) at 48 months
95% of children enrolled in kindergarten received 2 doses of MMR vaccine	94.9% (95% CI 90.3 – 99.6) at 48 months
95% of children enrolled in kindergarten received 3 or more doses of polio vaccine	96.2% (95% CI 91.6 – 100.0) at 48 months
95% of children enrolled in kindergarten received 3 or more doses of hepatitis B vaccine	91.3% (95% CI 86.8 – 96.0) at 48 months
95% of children enrollees in kindergarten received 2 or more doses of varicella vaccine	Not assessed [11]

[10] San Francisco EKRS 2015 did not include assessment of Hib, Hepatitis A, Rotavirus, or PCV vaccines.

[11] San Francisco EKRS 2015 included assessment of 1 varicella vaccine as required for kindergarten entry. The proportion who received 1 varicella vaccine by age 48 months was 84.3% (95% CI 80.0 – 88.7). See Table 4.