Predictors of Incomplete Vaccination Schedules Among Children and Adolescents in San Diego County During the COVID-19 Pandemic

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Danelle Wallace, MPH
Senior Epidemiologist
Epidemiology & Immunization Services Branch
Public Health Services

Introduction

Danelle Wallace, MPH
Senior Epidemiologist

- Vaccine Preventable Disease (VPD) and Immunization Epidemiologist at the County of San Diego

Background

- Incomplete childhood vaccination can occur due to a variety of reasons, including:
  - Parental consent, and
  - Access to healthcare.

- An incomplete vaccination schedule is when an individual is partially vaccinated against a disease because they received some, but not all, recommended shots.
  - This primarily concerns vaccination schedules with more than one recommended shot.

- On March 13, 2020, the United States declared a nationwide state of emergency as the novel coronavirus 2019 (COVID-19) rapidly spread.
  - The state of California followed suit with stay-at-home orders (SAHO) requiring the restriction of non-essential movement and business on March 17, 2020.

Background (cont.)

- The Coronavirus disease 2019 (COVID-19) pandemic changed the priorities of healthcare facilities.
- Caused many healthcare systems to stop performing routine screenings and health care appointments.
- Altered healthcare hours, lockdowns, and public fear to refer to medical centers caused a significant reduction in routine appointments.[1]

Background (cont.)

- Although healthcare services remained opened, there were decreases in routine vaccination screening and administration.[2]
- Some states observed relatively slow rebounds in childhood vaccination uptake after local restrictions eased, but rates struggled to return to pre-pandemic levels.[3]

Childhood Vaccines

- Many routine childhood vaccines have multiple doses and varied schedules.[5]
- Focus on inactivated polio (IPV), measles mumps and rubella (MMR), and varicella (VAR) vaccines due to gaps between doses.

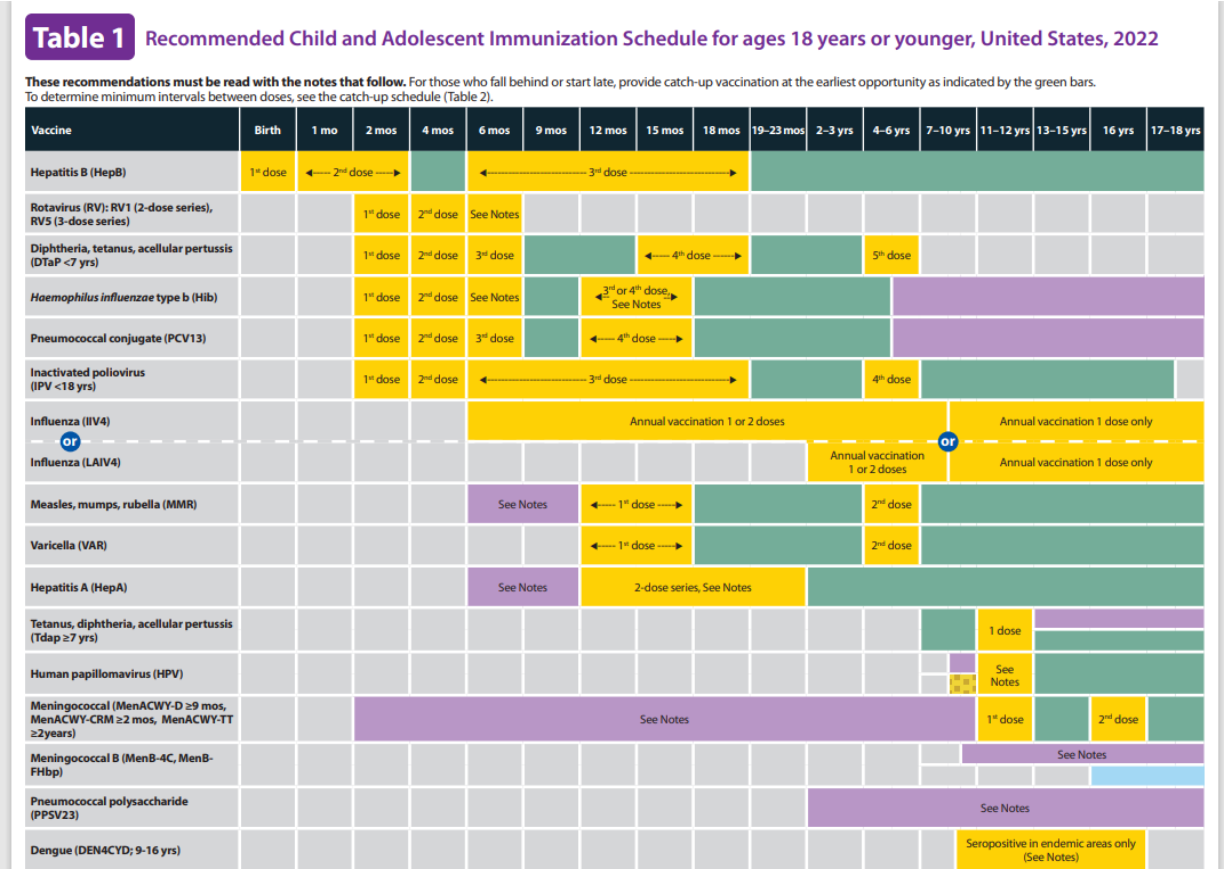

Table 1 Recommended Child and Adolescent Immunization Schedule for ages 18 years or younger, United States, 2022

These recommendations must be read with the notes that follow. For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars.
To determine minimum intervals between doses, see the catch-up schedule (Table 2).

Vaccine	Birth	1 mo	2 mos	4 mos	6 mos	9 mos	12 mos	15 mos	18 mos	19–23 mos	2–3 yrs	4–6 yrs	7–10 yrs	11–12 yrs	13–15 yrs	16 yrs	17–18 yrs
Hepatitis B (HepB)	1st dose	◄ 2nd dose ►			◄ 3rd dose ►												
Rotavirus (RV): RV1 (2-dose series), RV5 (3-dose series)			1st dose	2nd dose	See Notes												
Diphtheria, tetanus, acellular pertussis (DTaP <7 yrs)			1st dose	2nd dose	3rd dose			◄ 4th dose ►				5th dose					
Haemophilus influenzae type b (Hib)			1st dose	2nd dose	See Notes		◄ 3rd or 4th dose, See Notes ►										
Pneumococcal conjugate (PCV13)			1st dose	2nd dose	3rd dose		◄ 4th dose ►										
Inactivated poliovirus (IPV <18 yrs)			1st dose	2nd dose	◄ 3rd dose ►							4th dose					
Influenza (IIV4)					Annual vaccination 1 or 2 doses								Annual vaccination 1 dose only				
or																	
Influenza (LAIV4)											Annual vaccination 1 or 2 doses		Annual vaccination 1 dose only				
Measles, mumps, rubella (MMR)					See Notes		◄ 1st dose ►					2nd dose					
Varicella (VAR)							◄ 1st dose ►					2nd dose					
Hepatitis A (HepA)					See Notes		2-dose series, See Notes										
Tetanus, diphtheria, acellular pertussis (Tdap ≥7 yrs)														1 dose			
Human papillomavirus (HPV)														See Notes			
Meningococcal (MenACWY-D ≥9 mos, MenACWY-CRM ≥2 mos, MenACWY-TT ≥2years)			See Notes											1st dose		2nd dose	
Meningococcal B (MenB-4C, MenB-FHbp)														See Notes			
Pneumococcal polysaccharide (PPSV23)											See Notes						
Dengue (DEN4CYD; 9-16 yrs)													Seropositive in endemic areas only (See Notes)				

Research Questions

- What proportion of children and adolescents have incomplete IPV, MMR, and/or VAR series?
- Are there demographic and/or regional disparities regarding incompleteness?

Study Population

- Data were obtained from the San Diego Immunization Registry (SDIR).
- SDIR was the regional immunization registry for the County of San Diego until the switch to the California Immunization Registry (CAIR2) on April 25, 2022.
- Note that California is not a mandatory reporting state, so not all providers reported to SDIR.
- Records were subset to ages between 6 -19 years old by 12/31/2021.
- Observations, who were ineligible to receive their next dose due to CDC interval guidelines, were removed from the analysis.

Methods – Variables

- Variables of interest were age, gender, race or ethnicity, zip code, and IPV, MMR, and VAR.
- Zip codes were matched with the six San Diego County region boundaries.
  - Zip codes outside San Diego County were collapsed to variable “Out of jurisdiction” (OOJ).
  - Most recent zip code on record was used before sub-setting the data.
- Variables for IPV, MMR, and VAR were created to signify the highest dose received in each schedule.
  - Incompleteness was determined with a binary variable by categorizing the highest dose received as either the last dose of the schedule (complete) or not the last dose of the schedule (incomplete).
  - CDC vaccination schedules and interval guidelines were used to determine incompleteness.[6]

Methods – Statistical Analyses

- IBM SPSS Statistics Version 24 was used for data cleaning, descriptive statistics, and analysis.
- Pearson's correlations were used to identify potential collinearity.
- A X^2 analysis tested independence of incomplete vaccination series from gender.
- Kruskal-Wallis tests determined within-group differences for the race/ethnicity and region variables.
- Age was inversely transformed to allow for interpretation of odds as age values decreased.
- Adjusted and unadjusted models used binary logistic regression to determine odds of having an incomplete vaccination series.

Methods – Study Population

- There were over 500,000 children and adolescents included in the analysis.
- More than half of the study population were recorded as either Hispanic or White even with the inclusion of missing racial data (26%).
- Each of the six County HHSA Regions contained approximately 15% of the study population except for North Inland (19%) and South (20%).
- Overall rates of incomplete vaccination series were similar between MMR (20%) and VAR (21%) series, while the IPV rate was higher (27%).

Results – Descriptive Statistics

Table 1. Descriptive statistics	
Variable	**Value**
Total observations (n)	508,965
Years of age (mean ± SD)	12.4 ± 3.8
Gender (%)	
Male	50
Missing	1.7
Race (%)	
AI/AN	0.3
Asian	6
Black	3.6
Hispanic	28.8
NH/PI	0.4
Other	10.9
White	23.7
Missing	26.4
HHSA Region (%)	
Central	14.9
East	15.8
North Central	15
North Coastal	15.3
North Inland	19.1
South	20
IPV (%)	
Incomplete	25.5
Missing	3.6
MMR (%)	
Incomplete	18.5
Missing	6.4
VAR (%)	
Incomplete	19.7
Missing	7.1

- More than half of the study population were recorded as either Hispanic or White (26%).
- North Inland (19%) and South (20%) Regions had slightly higher percentages of included individuals.
- Rates of incomplete vaccination series were lower among MMR (18%) and VAR (19%) series than the IPV rate (25%).

Results – Incomplete Vaccinations

Table 2. Incomplete vaccination prevalence by vaccination series				
		Incomplete Series		
	All completed	IPV	MMR	VAR
Years of age (mean ± SD)	12.5 ± 3.8	12.0 ± 3.8	11.9 ± 3.7	12.1 ± 3.8
		Incomplete Prevalence (%)		
Variable		IPV	MMR	VAR
Male		26.2	19.3	20.8
Female		26	19.9	21.3
Race				
AI/AN		23.1	16.1	16.8
Asian		26.1	19.7	21.4
Black		25.6	16.5	18.1
Hispanic		17.3	14.2	15.4
NH/PI		21.4	15.4	16.7
Other		27.3	20.7	22.1
White		28.5	21.5	22.9
HHSA Region				
Central		22.6	15.2	16.7
East		31.2	21.3	22.9
North Central		25.4	21.3	23.3
North Coastal		27.3	21.2	22.2
North Inland		27.7	21.2	22.2
South		24.5	18.6	20.1

- Incompleteness of vaccination series was similar for males and females
- White children consistently had higher rates of incomplete vaccination series for all three antigens

Results – Unadjusted Model

Table 3. Unadjusted associations by vaccination series			
	Outcome		
	Incomplete IPV	Incomplete MMR	Incomplete VAR
Variable	**Estimated Odds (99% Confidence Interval)**		
Age (decrease 1 year)	1.03 (1.03 – 1.04)	1.05 (1.05 – 1.05)	1.03 (1.03 – 1.04)
Gender (Female)	0.99 (0.97 – 1.01)	1.04 (1.02 – 1.05)	1.03 (1.01 – 1.05)
Race/ethnicity			
AI/NA	0.75 (0.65 – 0.88)	0.70 (0.59 – 0.84)	0.68 (0.57 – 0.81)
Asian	0.89 (0.86 – 0.92)	0.90 (0.86 – 0.94)	0.92 (0.88 – 0.95)
Black	0.86 (0.83 – 0.91)	0.72 (0.69 – 0.77)	0.75 (0.71 – 0.79)
Hispanic	0.53 (0.52 – 0.54)	0.61 (0.59 – 0.62)	0.61 (0.60 – 0.63)
NH/PI	0.68 (0.59 – 0.78)	0.66 (0.57 – 0.78)	0.68 (0.58 – 0.79)
Other	0.95 (0.92 – 0.97)	0.95 (0.92 – 0.99)	0.95 (0.92 – 0.98)
White	*Reference*	*Reference*	*Reference*
HHSA Region			
Central	*Reference*	*Reference*	*Reference*
East	1.55 (1.51 – 1.60)	1.51 (1.46 – 1.57)	1.49 (1.44 – 1.54)
North Central	1.16 (1.13 – 1.20)	1.51 (1.46 – 1.57)	1.52 (1.47 – 1.57)
North Coastal	1.28 (1.24 – 1.32)	1.50 (1.45 – 1.56)	1.43 (1.38 – 1.48)
North Inland	1.31 (1.27 – 1.35)	1.51 (1.46 – 1.56)	1.43 (1.38 – 1.48)
South	1.11 (1.08 – 1.15)	1.56 (1.51 – 1.62)	1.26 (1.22 – 1.30)

Results – Adjusted Model

Table 4. Adjusted associations by vaccination series			
	Outcome		
	Incomplete IPV	Incomplete MMR	Incomplete VAR
Variable	**Estimated Odds (99% Confidence Interval)**		
Age (decrease 1 year)	1.07 (1.07 – 1.07)	1.08 (1.08 – 1.09)	1.06 (1.06 – 1.06)
Race/ethnicity			
AI/NA	0.58 (0.33 – 1.01)	0.58 (0.30 – 1.13)	0.59 (0.32 – 1.12)
Asian	0.71 (0.63 – 0.81)	0.55 (0.47 – 0.65)	0.60 (0.52 – 0.70)
Black	1.02 (0.92 – 1.13)	0.71 (0.63 – 0.81)	0.80 (0.71 – 0.91)
Hispanic	0.53 (0.49 – 0.58)	0.63 (0.57 – 0.69)	0.65 (0.59 – 0.72)
NH/PI	0.59 (0.40 – 0.88)	0.70 (0.45 – 1.07)	0.64 (0.42 – 0.99)
Other	0.83 (0.75 – 0.92)	0.82 (0.73 – 0.92)	0.83 (0.74 – 0.94)
White	*Reference*	*Reference*	*Reference*
HHSA Region			
Central	*Reference*	*Reference*	*Reference*
East	1.32 (1.22 – 1.43)	1.28 (1.17 – 1.41)	1.31 (1.20 – 1.44)
North Central	0.73 (0.67 – 0.79)	0.83 (0.75 – 0.91)	0.87 (0.79 – 0.95)
North Coastal	1.17 (1.08 – 1.27)	1.34 (1.22 – 1.47)	1.36 (1.24 – 1.49)
North Inland	1.28 (1.18 – 1.39)	1.46 (1.33 – 1.60)	1.44 (1.32 – 1.58)
South	1.12 (1.02 – 1.23)	1.36 (1.22 – 1.51)	1.35 (1.22 – 1.50)

Conclusion

- The association between decreasing age and increased odds of incomplete vaccination series can suggests that children eventually complete their vaccination series later into their adolescence.
  - Children transition into middle school and must meet school entrance requirements.
- Some racial differences and interactions were evident in modeling and could be used for health outreach and planning purposes.
- The high correlations of incompleteness between IPV, MMR, and VAR vaccination series suggests that many individuals had multiple incomplete series.
  - Providers have opportunities to vaccinate and bring children UTD.

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Questions?

Danelle Wallace, MPH

Senior Epidemiologist

Epidemiology and Immunization Services Branch

DanelleRuth.Wallace@sdcounty.ca.gov

(619) 629-1698

COUNTY OF SAN DIEGO HHSA HEALTH AND HUMAN SERVICES AGENCY

LIVE WELL SAN DIEGO

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