

Vaccination Trends and Family-Level Characteristics Associated With Incomplete or Delayed Childhood Immunizations: The Healthy Start Study

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Abstract

Purpose: Assess family-level factors associated with childhood immunization schedule adherence.

Design: Prospective cohort; Setting: The Healthy Start study enrolled 1,410 pregnant women in Denver, Colorado 2009-2014

Subjects: Children with available vaccination data in medical records (0-6 years old)

Measures: Vaccine schedule completion and compliance

Analysis: Logistic regression comparing family-level factors that differ based on vaccine schedule adherence

Results: Most immunizations required in Colorado for school entry were below national completion goals with 61.8% of participants (n = 532/861) completing the full vaccination series. Most participants received the first dose of individual vaccines on time (73.5% - 90.7%), but fewer received all doses on time (21.0% - 39.5%). Factors associated with not completing the vaccination series (OR [95% CI]) included: in-utero exposure to cigarette smoke (1.97 [1.41, 2.75]), single parent household (1.70 [1.21, 2.38]), children identified as non-White (Hispanic 1.40 [1.01, 1.94]; Black 1.88 [1.24, 2.85]; Other 2.17 [1.34, 3.49]), mothers not working outside the home (1.98 [1.46, 2.67]), and household income <\$70,000 per year (<\$40,000 1.93 [1.35, 2.75]; \$40,000-\$70,000 1.64 [1.09, 2.46]). Conversely, families with more educated mothers (0.47 [0.29, 0.76]) and older parents (0.97 [0.94, 0.99]) were significantly more likely to complete the series.

Conclusions: These findings may help identify groups at risk of immunization schedule non-adherence and may be used to target education/advocacy campaigns to reduce hesitancy and increase access in these populations.

Keywords

vaccines, disparities, delayed immunizations, vaccine adherence, interventions

Purpose

Immunizations that prevent potentially life-threatening diseases are required by individual states in the United States (U.S.) for entry into childcare and schools. Nearly all states require: diphtheria, tetanus, and pertussis (DTaP), Hepatitis B (Hep B), *Haemophilus influenzae type b* (Hib), measles, mumps, and rubella (MMR), inactivated polio vaccine (IPV), and varicella/chicken pox.¹ Several states also require Hepatitis A (Hep A), pneumococcal conjugate vaccine (PCV13), and rotavirus (RV).¹ All allow for medical exemptions, 84% allow for religious exemptions, and 35% allow for exemptions for other personal reasons.¹

The U.S. Centers for Disease Control and Prevention (CDC) publishes annually a recommended immunization schedule for children from birth through age six² but rates

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of immunization schedule adherence vary greatly across area of residence and groups in the U.S.³ Several factors related to the social determinants of health may play a role in parents' decisions to vaccinate their children including: income, insurance status, rurality, race, language spoken, education, parental age, family structure, and employment status.³⁻¹³ The most commonly reported characteristics associated with lower immunization rates include parents with a lower household income^{3,5-8,11} and less education,^{4,6,8} and families who self-identify as non-White.^{3,6-8,11,12} No studies have examined possible factors correlated with vaccine decision-making in the Mountain West. We aimed to identify family-level characteristics that differ between families whose children are fully vaccinated and vaccinated on schedule compared to those who delay or choose not to vaccinate.

Methods

Design

Healthy Start is a prospective pre-birth cohort study that enrolled 1,410 women early in pregnancy from a single obstetrics clinic in Colorado (2009-2014). 21 pregnancies ended in fetal demise resulting in study exclusion.

Sample

Immunization dates were abstracted from the medical records of all providers listed by participating families or queried by Health Data Compass Data Warehouse project (healthdatacompass.org). Of 1,389 potentially eligible participants, 861 (61%) children had any documentation of vaccination/non-vaccination and were included in this analysis. We excluded 528 with incomplete vaccine information from the main analysis.

Measures

Based on CDC recommendeds² and Kurosky et al¹⁴ we calculated measures of vaccine completion and compliance for individual immunizations and the full series (DTaP, IPV, MMR, Hib, Hep B, Varicella, and PCV). Completion of the required number of doses, was summarized through age six. Being severely undervaccinated for any vaccine was defined as seven or more months late on any dose.¹⁴ Participants who were severely under vaccinated for one or more vaccine were classified as having delayed immunization.

A PubMed search of literature published in the last 10 years (October 17, 2011-2021) was used to select family-level characteristics using keywords "vaccine hesitancy" and "vaccine compliance". Only studies in English that included quantitative analysis of family-level characteristics (n = 10) were included ([Supplemental Table 1](#)). We selected predictors

from previous studies as well as some novel predictors based on data availability and theory.

Analysis

We used logistic regression to evaluate family-level characteristics associated with vaccine series completion (yes/no) or delayed immunizations (yes/no) as the outcome and each of the various family-level characteristics as predictors in separate models. Analyses were performed using SAS v.9.4 (SAS Institute, Cary, NC).

Results

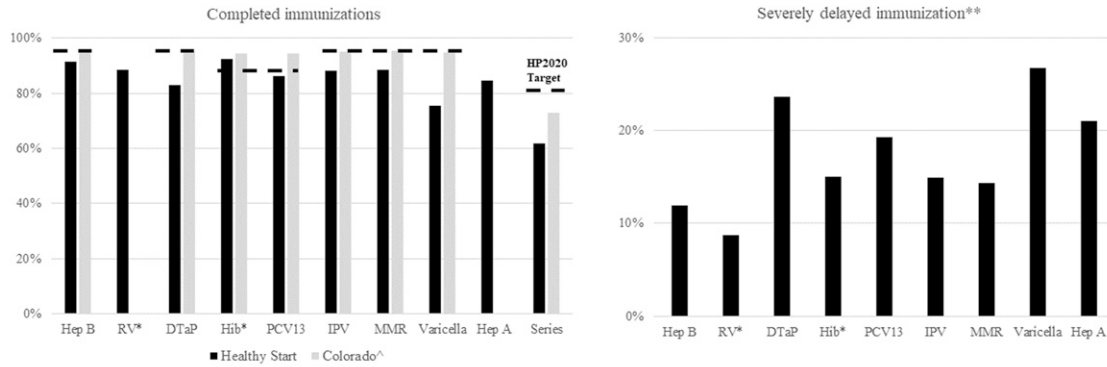
The analytic sample consists of 52.9% male children, and includes 48% Non-Hispanic white, 29% Hispanic, 14% Non-Hispanic Black, and 10% other reported race/ethnicity. The average maternal age was 28 years and paternal age was 30 years. During pregnancy, 8% of mothers reported smoking and 23% had exposure to secondhand smoke. Where income information was available, 43% reported making >\$70,000 per year. 98% of participants lived in urban census tracts, 27% received women, infant and children (WIC) program benefits at the time of enrollment, and 20% were single mothers. The median number of children in each participating household was two (range: 1-8). 14% of mothers reported having completed <12th grade. 91% of participants spoke English (91%) and 64% were employed outside the home at enrollment.

We compared completion rates for each vaccination through age six to Colorado school-age children ([Figure 1](#)); all school-based estimates were higher. Overall, 46% of participants (n = 395) were severely delayed on receiving one or more immunization ([Figure 1](#)).

Several factors were associated with not completing the full series ([Table 1](#)) including: secondhand smoke exposure during pregnancy, having a single parent, reporting race/ethnicity as Hispanic, Non-Hispanic Black or Non-Hispanic Other, children from the lower (<\$40,000 per year) and middle (\$40,000-\$70,000 per year) income groups, recipients of WIC benefits or having a mother that doesn't work outside the home.

Conversely, children with older parents, a mother with a graduate degree, and a higher birthweight (+1000 g change, OR=0.72 [95% CI: 0.55, 0.93]) had lower odds of non-completion. The following factors were not associated with series completion: number of children in the household, child sex, residence in a rural census tract, and mother's language.

When evaluating delayed immunization as the outcome, all associations were of similar magnitude and direction to the results for non-completion ([Table 1](#)), except for maternal smoking during pregnancy, child birthweight, and maternal education. Children with mothers who smoked



Notes:
 *Depending on the specific brand or combination vaccine received for RV and Hib, different numbers of doses are required. Information about which brand of vaccine a child received was unavailable, therefore we assumed those with the lower number of doses followed the national recommendations.
 ^Colorado estimates for single vaccines are from the 2020/2021 school-based survey conducted by the Colorado Department of Public Health and Environment for kindergarten entry and childcare. Estimates for the 4:3:1:3:3:1:4 series are from the Colorado Immunization Information System for the period between January 1, 2020 and June 30, 2020.
 **Severely delayed is defined as seven or more months late on any dose.

Abbreviations:
 HP2020 = Healthy People 2020; Hep B = Hepatitis B; RV = Rotavirus; DTaP = Diphtheria, tetanus, and pertussis; Hib = *Haemophilus influenzae* type b; PCV = Pneumococcal conjugate vaccine; IPV = inactivated polio vaccine; MMR = Measles, mumps, and rubella; Hep A = Hepatitis A.

Figure I. Left: Comparison of observed completed immunizations (Black) to estimates for Colorado (Gray). Healthy People 2020 (HP2020) targets (dashed line). Right: Summary of observed severely delayed immunizations.

Table I. Family-Level Characteristics Significantly Associated With The Odds Of Not Completing The Full Vaccine Series Or Delaying Immunization.

Characteristic (Reference or Change)	Not Completing Series OR (95% CI)	Delaying Immunization OR (95% CI)
Exposed to secondhand smoke during pregnancy (no exposure)	1.97 (1.41, 2.75)	2.14 (1.53, 2.98)
Mother's age at birth of child (+1 year)	0.97 (0.94, 0.99)	0.96 (0.94, 0.98)
Father's age at birth of child (+1 year)	0.98 (0.96, 1.00)	0.97 (0.95, 0.99)
Single parent (not single parent)	1.70 (1.21, 2.38)	1.71 (1.22, 2.38)
Mother reports graduate degree (<12 th grade)	0.47 (0.29, 0.76)	0.40 (0.25, 0.64)
Child reported Hispanic race/ethnicity (Non-Hispanic White)	1.40 (1.01, 1.94)	1.60 (1.17, 2.20)
Child reported Non-Hispanic Black race/ethnicity (Non-Hispanic White)	1.88 (1.24, 2.85)	2.08 (1.38, 3.15)
Child reported Non-Hispanic Other race/ethnicity (Non-Hispanic White)	2.17 (1.34, 3.49)	2.11 (1.31, 3.40)
Household income <\$40,000 (>\$70,000)	1.93 (1.35, 2.75)	2.06 (1.46, 2.92)
Household income \$40,000 – \$70,000 (>\$70,000)	1.64 (1.09, 2.46)	1.79 (1.21, 2.65)
Received WIC benefits mid-pregnancy (did not)	1.45 (1.03, 2.05)	1.64 (1.16, 2.31)
Mother not employed outside the home mid-pregnancy (employed)	1.98 (1.46, 2.67)	1.92 (1.44, 2.58)

Note. Data were missing for the following variables: 61 secondhand smoke, 8 father's age, 5 number of children in household, 2 single parent, 6 language, 159 household income, 187 WIC benefits, 41 census tract, 71 maternal employment status.

during pregnancy were 2.27 (95% CI: 1.36, 3.77) times more likely to have delayed immunizations compared to children with mothers who did not smoke. Higher birth-weight was not associated with lower odds of delaying immunizations. Children of mothers who graduated college were significantly less likely to have delayed immunizations compared mothers who had <12th grade education (OR=0.57 [95% CI: 0.36, 0.91]).

Discussion

Summary

In an ethnically and socioeconomically diverse cohort of mothers and children in the Denver Metro Area, we observed several factors associated with childhood vaccine completion and compliance through age six. Completion rates ranged from 61.8% to 92.3%, and 45.9% delayed at least one immunization for

seven months or more. The groups most likely to not complete the required series or to delay vaccinations in this cohort include mothers who reported smoking exposure during pregnancy, single parents, children identified as a race other than non-Hispanic white, families with household incomes <\$70,000 per year, and mothers not employed outside the home. Conversely, children with older or more educated mothers were more likely to complete all required vaccinations in the series and not delay immunizations.

Limitations

We used medical records to obtain vaccination dates. This could result in missing data, which may bias our completion and compliance rates and make them less comparable to other surveys. Many of the family-level variables rely on self-reported data collected at a single time point, which may be subject to misclassification. Prediction, rather than causal inference, was the primary purpose of this analysis; we did not conduct any multivariable models where predictors were mutually adjusted. Some of the associations presented in this study could be explained by multiple factors.

Significance

Immunization completion and compliance in this cohort are slightly lower than national targets for several vaccines, and many children received vaccinations on a delayed schedule. Several important family-level characteristics identified in this study associated with non-adherence may inform targeted interventions to improve immunization rates.

So What?

What is already known about this topic?

At the national level several groups are less likely to receive childhood immunizations or delay getting them.

What does this article add?

In Colorado, children with exposure to cigarette smoke, living with a single parent, with lower household income, and whose mothers are not employed outside the home may be at high risk of non-adherence to vaccine schedules.

What are the implications for health promotion practice or research?

Identified family-level characteristics may be used to inform targeted interventions.

Author Contribution

Conceptualization: LZB, APS. Data collection: TAB, DD. Data interpretation: LZB, APS, DHG, TAB, JMN, JLA, JMB, DD. Manuscript preparation: LZB. Manuscript review: APS, DHG, TAB, JMN, JLA, JMB, DD. Funding acquisition: DHG, DD.

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Declaration of Conflicting Interests

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Ethics Statement

Participants provided written informed consent prior to enrollment and study procedures were approved by the Colorado Multiple Institutional Review Board (COMIRB) under protocol #09-0563.

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Supplemental Material

Supplemental material for this article is available online.

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