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## Vaccine shot-limiting: Estimating the prevalence, indicators, and impact on vaccination status – Michigan, 2012

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### ABSTRACT

**Background:** Concerns regarding vaccine safety and pain have prompted certain parents to limit the number of shots their child receives per visit. We estimated the prevalence of shot-limited children in Michigan, described their characteristics, assessed whether shot-limited children were up-to-date on recommended vaccinations, and investigated possible intervention points for vaccination education.

**Methods:** We analyzed vaccination registry and birth record data of children born in Michigan during 2012 who had  $\geq 2$  vaccination visits, with  $\geq 1$  visits after age 5 months. Shot-limited was defined as receiving  $\leq 2$  shots at all visits through age 24 months. Nonlimited children received  $> 2$  shots at  $\geq 1$  visits. Up-to-date vaccination was based on receipt of a seven-vaccine series and was determined at ages 24 months and 35 months. Risk ratios (RR) were calculated using risk regression.

**Results:** Of 101,443 children, a total of 2,967 (3%) children were shot-limited. Mothers of shot-limited children were more likely to be white (RR: 1.2; 95% confidence interval [CI]: 1.2–1.2), college graduate (RR: 1.9; 95% CI: 1.9–2.0), and married (RR: 1.5; 95% CI: 1.5–1.5). Compared with nonlimited children, shot-limited children were more likely to be born in a nonhospital setting (RR: 11.7; 95% CI: 9.4–14.6) and have a midwife attendant (RR: 1.9; 95% CI: 1.7–2.1). Shot-limited children were less likely to be up-to-date on recommended vaccinations (RR: 0.2; 95% CI: 0.2–0.3); this association was stronger for those with a midwife birth attendant (RR: 0.1; 95% CI: 0.1–0.2) rather than a medical doctor (RR: 0.3; 95% CI: 0.2–0.3).

**Conclusions:** Shot-limited children are less likely to be up-to-date on vaccinations, possibly leading to increased risk for vaccine-preventable diseases. This association was stronger for those with a midwife birth attendant. This analysis should prompt targeted education, such as to midwives, concerning risks associated with shot-limiting behavior.

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### 1. Introduction

Vaccinations play an integral role in decreasing the incidence of communicable diseases and preventing childhood morbidity and mortality. The Advisory Committee on Immunization Practices (ACIP) currently recommends children receive vaccinations against 14 diseases by age 19 months [1]. One of the goals of the U.S. Department of Health and Human Services Healthy People 2020 initiative is to achieve 80% vaccination coverage among children

aged 19–35 months for a seven-vaccine series [2]. Concerns have been raised that receiving multiple vaccinations at once might overwhelm the immune system or lead to increased adverse events because of perceived vaccine toxicity; however, these concerns are not scientifically supported [3,4]. Parents also worry about the pain associated with receiving multiple shots in a single clinic visit [5]. These apprehensions have led certain parents to deviate from the recommended ACIP schedule by eliminating certain vaccines or decreasing the number of vaccines their child receives per visit [6]. A study utilizing data from the 2003 National Immunization Survey (NIS) indicated that 22% of parents reported intentionally delaying their child's vaccinations, and those children had lower vaccination coverage by age 19 months, compared with

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children of parents who did not report delaying vaccinations (35% versus 60%,  $p < 0.05$ ) [7]. In a national survey of pediatricians and family physicians, 93% of providers reported being asked to spread out vaccinations and 23% reported an increase in these requests, compared with the previous year [8]. Despite acknowledging that vaccination delays put children at risk for vaccine-preventable diseases, 74% of providers are willing to consider such requests, citing a need to build trust with families and maintain them in their practice [8]. Without additional and more frequent vaccination visits, children whose parents follow deviant vaccination schedules risk not being up-to-date with recommended vaccinations and under-vaccination has been associated with outbreaks of vaccine-preventable diseases including pneumococcal disease, pertussis, and measles [9–11]. These diseases can cause morbidity and mortality, particularly in children, highlighting the benefits of conforming to ACIP-recommended vaccination schedules and not delaying vaccinations [12].

According to the ACIP-recommended schedule, a child might receive up to nine injectable vaccines (shots) at a single well-child visit [1]. Combination vaccines can be used to decrease the number of shots; however, to be up-to-date by 19 months without additional visits, a child would still need to receive  $>2$  shots at at least one visit. Immunization information systems (IIS) data have been used to identify children of parents who limit the number of shots their child receives per visit, herein referred to as shot-limited. In Oregon, the proportion of shot-limited children increased from 3% in 2006 to 10% in 2009 [13]. These children were less likely to be up-to-date on any vaccination series by age 9 months, compared with nonlimited children.

The extent of vaccine shot-limited children in Michigan and the impact on vaccination status has not been evaluated by using IIS data. This analysis is important because the seven-vaccine series coverage in Michigan, as measured by the 2015 NIS, was 68%, which is below the Healthy People 2020 target of 80% [14]. We hypothesized that the demographics of shot-limited children differed from nonlimited children and shot-limited children were less likely to be up-to-date on vaccinations. Specifically, we hypothesized the type of birth attendant (doctor or midwife) was associated with shot-limited children and may change the relationship between shot-limited children and up-to-date status. The objectives of this analysis were to estimate the prevalence of shot-limited children among those born in Michigan in 2012, describe the epidemiology of shot-limited children, investigate the association between shot-limited children and up-to-date vaccination status, and identify vaccines that parents of shot-limited children might be more likely to delay. Ultimately, understanding the extent of vaccine shot-limiting and associated risks will be useful in targeting public health strategies that emphasize the importance of timely vaccination practices.

## 2. Methods

Analysis was conducted in September 2015. Michigan vaccination providers are required to report vaccinations provided to children aged  $<20$  years to the Michigan Care Improvement Registry (MCIR), Michigan's web-based IIS. For this retrospective, longitudinal cohort study, vaccination data were obtained from the MCIR for children born in Michigan during January 1, 2012–December 31, 2012. Each unique vaccination date recorded in the MCIR was considered a vaccination visit. To minimize accounting for children who moved out of state, we included children who had at least two MCIR-recorded vaccination visits by age 24 months, with at least one visit after age 5 months. This, by default, excluded children whose parents refused all vaccines. Children who died (452, 0.4%), children without a Michigan county residence (2145, 1.9%),

or children whose parent/guardian opted out of the registry (152, 0.1%) were excluded. These criteria are similar to those applied in the Oregon study on shot-limited children [13]. For the remaining children, we recorded the number of MCIR-recorded vaccination visits by age 24 months, which included the Hepatitis B vaccine birth dose. All vaccination shots were included. Combination vaccines were counted as a single shot.

Additional demographic data were obtained from Michigan's electronic birth record system. Variables included the following: maternal race (white, black, Asian, American Indian); maternal ethnicity (Hispanic, non-Hispanic); maternal highest level of education completed (some high school, high school graduate, some college, college graduate or higher); maternal marital status at time of delivery (married, not married); birth setting (hospital, nonhospital which includes nonhospital affiliated birthing centers, home, and other); and the type of healthcare provider who attended the delivery (midwife including certified nurse midwife, and medical doctor, including doctor of medicine or doctor of osteopathic medicine). Vaccination data were linked to electronic birth record data via a unique ID that is present in both the electronic birth record and the MCIR.

Survey data indicate that pain is one reason parents chose to delay vaccinations [5]; therefore, our analysis focused on injectable vaccines (shots). Vaccines were limited to provider-verified, valid doses. Valid doses are those administered after minimum ages and minimum intervals, consistent with ACIP recommendations [1]. Shot-limited children were defined as those who received  $\leq 2$  shots at every vaccination visit from birth through age 24 months [13]. In other words, shot-limited children never received  $>2$  shots at any visit. Conversely, nonlimited children were defined as those who had at least one vaccination visit between birth and age 24 months, in which  $\geq 3$  shots were received. Nonlimited children might have received 1–2 shots at a visit as long as they received 3 or more shots at another visit.

A child was considered up-to-date if he or she received the combined seven-vaccine series, which consists of at least the following: four doses of diphtheria, tetanus toxoids, and acellular pertussis vaccine (DTaP); three doses of poliovirus vaccine (IPV); one dose of measles, mumps, and rubella vaccine (MMR); three or four doses of *Haemophilus influenzae* type b vaccine (Hib) depending on product type; three doses of hepatitis B vaccine (HepB); one dose of varicella vaccine (Var); and four doses of pneumococcal conjugate vaccine (PCV). This definition has been implemented previously to assess vaccination coverage using NIS data [14]. Up-to-date status was assessed at age 24 months, 5 months after a child should be up-to-date if conforming to the ACIP-recommended schedule, and again at age 35 months to allow additional catch-up time. The number of vaccinations required to be up-to-date does not change between ages 24 months and 35 months. Children who had not reached age 35 months at the time the data were obtained were excluded from the up-to-date calculation at 35 months ( $n = 15,836$ ).

Demographic data were compared by using risk ratios (RR) and 95% confidence intervals (CI). All risk ratios were calculated by using risk regression and adjusted for maternal race and education, a priori-defined sociodemographic confounders. When an outcome is common ( $>10\%$ ) and the sample size is at or near population level, relative risk is considered a better estimator of risk than odds ratios [15]. To test the interaction of the a priori hypothesis for midwife birth attendants, we included it as an interaction term in a separate multivariate risk regression. Statistical analysis was performed using SAS<sup>®</sup> software version 9.3 (SAS Institute, Cary, North Carolina, USA).

Because this analysis contributes directly to the control and prevention of disease, the investigation was deemed not human subjects research by Michigan Department of Health and Human

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