Influenza Vaccination of Michigan Children by Provider Type, 2010–2011

Joshua L. Clayton, PhD, MPH, Rachel C. Potter, DVM, MS, Eden V. Wells, MD, MPH, Cristi A. Carlton, MPH, Matthew L. Boulton, MD, MPH

Background: Influenza vaccination for all children aged 6 months to 18 years has been recommended since 2008 to prevent flu-related morbidity and mortality. However, 2010–2011 influenza vaccine coverage estimates show under-vaccination in children of all ages. We examined predictors of influenza vaccination in Michigan during the 2010–2011 influenza season.

Purpose: To determine whether immunization provider type was associated with a child's influenza vaccination in Michigan and assess whether county-level factors were confounders of the association.

Methods: Influenza vaccinations reported to the Michigan Care Improvement Registry from the 2010–2011 influenza season were analyzed in 2012 to estimate ORs for the association between immunization provider type and influenza vaccination.

Results: Among 2,373,826 Michigan children aged 6 months through 17 years, 17% were vaccinated against influenza and lower vaccination rates were observed for public compared to private providers (13% vs 18%). In the unadjusted model, public providers had lower odds of vaccinating children compared to private providers (OR=0.60, 95% CI=0.60, 0.61). County-level factors, including percentage of families living below the poverty line, median household income, and percentage black race, were not shown to confound the association. In the adjusted models, public providers had lower odds of vaccinating children compared to private providers (OR=0.87, 95% CI=0.86, 0.88).

Conclusions: Although a child's likelihood of influenza vaccination in Michigan varies by provider type, more effective strategies to improve influenza vaccination rates for all Michigan children are needed.

(Am J Prev Med 2014;47(1):46–52)

Introduction

Vaccination is the cornerstone of public health strategies to prevent significant influenza-related morbidity and mortality among children in the U.S.[1] Since 2008, the Advisory Committee on Immunization Practices (ACIP) has recommended annual influenza vaccination for all children aged 6 months through 18 years.[2] The ACIP implemented the recommendations in stages: first for children aged 6–23 months in 2004, then children aged 24–59 months in 2006, and finally children aged 5–18 years in 2008.[2–4]

During the 2009–2010 influenza season, the ACIP recommendations were revised to include an influenza A (H1N1) monovalent vaccine that protected against the H1N1 pandemic virus.[5] Despite the ACIP recommendations, data suggest that children of all ages are under-vaccinated against influenza.[6] Limited research has examined potential factors impacting childhood influenza vaccination rates since the ACIP recommendation changes in 2008.

Differences in childhood vaccination rates by immunization provider exist, making provider type an important predictor for influenza vaccine uptake.[7–13] Higher vaccination rates for routine childhood immunizations were documented in private compared to public providers.[9–12] Additionally, one study[8] showed higher influenza vaccination rates in children aged 6–23 months if

From the Department of Epidemiology (Clayton, Wells, Boulton), University of Michigan School of Public Health, Ann Arbor; and the Division of Immunization (Potter, Carlton), Michigan Department of Community Health, Lansing, Michigan

Address correspondence to: Joshua L. Clayton, PhD, MPH, University of Michigan School of Public Health, 1415 Washington Heights, Ann Arbor MI 48109. E-mail: nakolus@umich.edu.

0749-3797/$36.00
http://dx.doi.org/10.1016/j.amepre.2014.03.002

the child received the vaccine from a private versus public immunization provider. Following ACIP recommendation changes, no studies have examined the role of immunization provider on childhood influenza vaccination rates.

In addition to provider type, community characteristics of where a child lives influences the likelihood of receiving vaccinations, generally, and influenza vaccination, specifically.[14,15] Communities with higher median family income, higher percentage of residents living above the poverty line, and higher percentage of non-Hispanic white children aged <5 years have demonstrated higher vaccination rates.[14,15] These factors may directly impact vaccination owing to greater emphasis on preventive care in healthier, wealthier communities.[14] No studies have specifically examined if these community characteristics are confounders of the association between immunization provider type and influenza vaccination.

In this study, data from the 2010–2011 influenza season in the Michigan Care Improvement Registry (MCIR) were analyzed to (1) assess whether provider type is associated with childhood influenza vaccination; (2) determine whether the association remained while accounting for county-level confounders; and (3) identify whether age modifies the association.

Methods

Influenza vaccination data were drawn from MCIR, Michigan's web-based immunization information system in operation since 1998. Immunization providers electronically input vaccinations for people of all ages into MCIR. Under Michigan's public health code,[16] immunization providers are required to report school-exclusionary vaccinations to MCIR if the individual was born after December 31, 1993, and is younger than age 20 years. Influenza reporting became mandatory on August 7, 2012, when the rules were revised to include all immunizations administered to children and not just those required for school and child care.

MCIR is continually populated with the electronic birth certificates of all children born in Michigan after December 31, 1993; children moving to Michigan are entered into MCIR by their healthcare providers when a given child receives any immunization or their historic doses are input into the system. Electronic birth certificate reporting of mother's race was added to MCIR on January 1, 2005.

The study eligibility criteria were children aged 6 months through 17 years as of August 2, 2010, in-state residence according to MCIR, and presence of any provider-verified immunization record in MCIR. A small percentage of children (6.8%) were excluded because no immunization provider was assigned as a provider point of contact. MCIR does not assign a provider point of contact to children if the only doses reported to the registry were historic (i.e., not reported by the administering provider) or if the only immunizations they have received are influenza vaccines (including H1N1) or the birth dose of hepatitis B.

Influenza vaccinations reported to MCIR were examined for all Michigan residents aged 6 months through 17 years during the 2010–2011 influenza season, defined inclusively as August 2, 2010, through June 30, 2011. This period coincided with the first date that the influenza vaccine was available in Michigan and the last date before the vaccine expired. A child's demographic record in MCIR included date of birth; mother's race (for children born in Michigan); county of residence; and provider point of contact. Each vaccination record included the influenza vaccine provider, vaccine funding source, date of vaccine administration, and type of vaccine administered.

An immunization provider was defined as any healthcare provider that administers vaccines and is a registered MCIR user. A public immunization provider designation was assigned for local health departments, Federally Qualified Health Centers, Rural Health Centers, Indian Health Service clinics or tribal clinics, community/migrant health centers, and Women Infants and Children clinics. A private immunization provider designation was assigned for nongovernmental providers, faculty medical practices, HMOs, and private hospitals.

Provider point of contact matched the provider administering the current season's influenza vaccine for 71% of children by simple agreement. Provider point of contact was preferred over the administering provider in this analysis because, as the usual source of care, they would have the most influence on a child's receipt of vaccines.

Children were placed into the four following age groups to match the expansions of the ACIP recommendations and the age ranges used in CDC influenza vaccination coverage estimates: 6–23 months, 24–59 months, 5–12 years, and 13–17 years. Mother's race was categorized as white, black, American Indian, Chinese, Filipino, other Asian or Pacific Islander, other non-white, and other. Information on mother's race was missing for all children aged >5 years because the data were only available in MCIR starting in 2005. Therefore, race was not included in the primary analysis.

Vaccine funding sources were identified as the funding source of a child's last vaccine dose received prior to August 2, 2010, excluding the hepatitis B birth dose for which vaccine funding source is not available, and H1N1 vaccines, all of which were publicly funded, and historic data. Vaccine funding sources were categorized as Vaccines for Children (VFC); private/self-insurance; and other.

VFC is a federal program providing free vaccines for eligible children against 16 diseases, including influenza, as recommended by the ACIP. To qualify for VFC, children must be aged <19 years, Medicaid-eligible, uninsured, American Indian/Alaskan Native, or underinsured. All of the public immunization providers administered VFC vaccines. Although VFC vaccines are not administered by all private immunization providers, the majority of VFC-eligible doses were administered by private providers.

Michigan county-level factors from the 2010 census were used as proxies for community characteristics and linked to the child's county of residence. There are 83 counties in Michigan, which vary in demographic characteristics, income, and education level. County-level factors included the percentage unemployed, median household income, percentage of families living below the federal poverty line in the past 12 months, percentage of black residents, and percentage of families with a female head of household with children aged <18 years. The percentage of black residents in a county was used as a proxy measure for racial composition, as blacks constitute the largest minority presence in Michigan's population at 14% overall.

Childhood influenza vaccination during the 2010–2011 influenza season was the outcome of interest. A child was defined as vaccinated if he or she received the recommended number of influenza vaccine doses for his or her age and vaccination history, based on ACIP recommendations.[1] The ACIP recommendations were more complex than in past years given the use of both a monovalent H1N1 influenza vaccine and seasonal influenza vaccine during the previous season. As such, the ACIP developed an algorithm for the 2010–2011 season to determine the number of influenza doses a child required to be considered vaccinated.[1] Children without an influenza vaccine in MCIR or receipt of only one dose when two doses were recommended based on the algorithm were considered unvaccinated.

Statistical Analysis

Data analysis was conducted in 2012. Univariate and bivariate statistics were calculated to describe the study population. To evaluate the relationship between immunization provider and influenza vaccination (Model 1), ORs and 95% CIs were estimated using generalized linear mixed models with a random intercept for county for logistic regression using the GLIMMIX procedure in SAS, version 9.2 (SAS Institute Inc., Cary NC). Generalized linear mixed models accounted for clustering of risk factors by county units, resulting in counties being more homogeneous with regard to the likelihood of a child being vaccinated.

In the multivariable analysis, covariates were included in the adjusted model (Model 2) if they were considered confounders either a priori (e.g., age, provider visit in the past 12 months, and vaccine funding source) or if the change in estimate criteria on the OR scale was $>10\%$ and statistically significant when confounders were added to the model. The approach led to the most parsimonious model with the greatest statistical efficiency. An interaction between immunization provider and age examined effect modification of the relationship with influenza vaccination (Model 3). This study was exempted from patient consent by the Michigan Department of Community Health IRB (#937-PHAEPI) and the University of Michigan IRB (HUM00047622).

Results

A total of 2,373,826 children aged 6 months through 17 years from MCIR were eligible for inclusion in the study. Of these, 394,881 (17%) were vaccinated against influenza. Coverage decreased with increasing age: 27% in 6–23-month-olds, 18% in 24–59-month-olds, 15% in 5–12-year-olds, and 13% among 13–17-year-olds (Table 1).

Among the 394,881 children vaccinated for influenza, 81% (n=318,571) had a private provider designated as the point of contact and 19% (n=76,310) had a public provider. The influenza coverage rate for all children served by a private provider was only slightly higher (18%) than the rate for those served by a public provider (13%) (Table 1). Children with an immunization provider visit in the past 12 months had higher coverage (27%) compared to those with no visits (8%).

Children with a private/self vaccine funding source (22%) also had higher influenza vaccination rates than children whose vaccine funding sources was VFC-eligible (16%). Although statistically significant, only small differences between vaccinated and unvaccinated children were observed for the county variables. The percentage of black residents differed the most among all county variables for vaccinated (13%) and unvaccinated children (16%).

Using logistic regression, children with a public provider had 40% lower odds of being vaccinated against influenza compared to children with a private provider (OR=0.60, 95% CI=0.60, 0.61; Model 1, Table 2). The association was attenuated when child's age, immunization provider visit in the past 12 months, and vaccine funding source were added to the model (OR=0.87, 95% CI=0.86, 0.88). The association was not further attenuated when county-level variables including median household income, percentage of families living below the poverty line in the past 12 months, and percentage of black residents were added to the model (OR=0.87, 95% CI=0.86, 0.88; Model 2, Table 2).

In order to better understand the role of mother's race in this analysis, a separate analysis of children aged 6–59 months was conducted. The children of white mothers received vaccines more often than the children of black mothers, 24% versus 11%, respectively. Because race is associated with provider type, after adding race to the adjusted model, the provider point of contact was no longer a significant predictor of influenza vaccination (OR=0.99 for public vs private, 95% CI=0.97, 1.01). Children with mothers of black race had 47% lower odds of being vaccinated and children with Chinese mothers had 47% greater odds of being vaccinated compared to children with mothers of white race, after controlling for the covariates in Model 2 (data not shown).

The relationship between immunization provider and influenza vaccination was examined for modification by child's age in four age groups: 6–23 months, 24–59 months, 5–12 years, and 13–17 years. Although the odds of vaccination varied by age in the adjusted model (Model 2, Table 2), the interaction model showed a statistically significant decrease in the odds of vaccination for public versus private providers for children of all age groups (6–23 months, OR=0.87, 95% CI=0.85, 0.90; 24–59 months, OR=0.86, 95% CI=0.84, 0.88; 5–12 years, OR=0.86, 95% CI=0.84, 0.87; 13–17 years, OR=0.91, 95% CI=0.89, 0.93; Model 3, Table 2). The relationship between immunization provider and influenza vaccination varied slightly by age, with the greatest difference observed between 5–12-year-olds and 13–17-year-olds when comparing the public–private provider association.

Table 1. Characteristics of Michigan pediatric influenza vaccination, 2010–2011 seasons, *n* (%) unless otherwise noted

Variable	Vaccinated[a]	Unvaccinated	Chi-square *p*-value	*n*
Provider point of contact			**<0.0001**	2,373,826
Public	76,310 (13)	527,836 (87)		
Private	318,571 (18)	1,451,109 (82)		
Mother's race[b]			**<0.0001**	515,934
White	92,046 (24)	296,890 (76)		
Black	10,555 (11)	84,120 (89)		
American Indian	652 (23)	2,129 (77)		
Chinese	3,039 (36)	5,397 (64)		
Filipino	1,756 (24)	5,477 (76)		
Other Asian or Pacific Islander	1,662 (25)	4,983 (75)		
Other non-white	1,065 (20)	4,270 (80)		
Unknown	367 (19)	1,526 (81)		
Age group			**<0.0001**	2,564,665
6–23 months	49,967 (27)	132,354 (73)		
24–59 months	70,100 (18)	327,502 (82)		
5–12 years	183,799 (15)	1,003,056 (85)		
13–17 years	101,365 (13)	696,512 (87)		
Immunization provider visit in past 12 months			**<0.0001**	2,389,934
Yes	288,098 (27)	772,753 (73)		
No	109,251 (8)	1,219,832 (92)		
Vaccine funding source			**<0.0001**	1,859,173
VFC	154,394 (16)	824,614 (84)		
Private/self	192,517 (22)	666,211 (78)		
Other	4,742 (22)	16,695 (78)		
County variable (M [SD])				
Unemployed, %	11.1 (2.9)	11.9 (3.0)	**<0.0001**	2,564,665
Median household income	$50,018 (9,097)	$49,016 (8,966)	**<0.0001**	2,564,665
Families below poverty line, %	10.3 (3.8)	11.0 (4.0)	**<0.0001**	2,564,665
Black race, %	13.0 (12.7)	15.6 (14.2)	**<0.0001**	2,564,665
Female head of household, %	7.2 (1.9)	7.6 (2.1)	**<0.0001**	2,564,665

Note: Boldface indicates statistical significance.
[a]Vaccinated according to Advisory Committee on Immunization Practices recommendations.[15]
[b]Data represent children aged 6–59 months; first available from birth certificate in 2005.
VFC, Vaccines for Children

Discussion

Michigan children with a private, rather than public, provider designated as their point of contact were significantly more likely to be vaccinated against influenza during the 2010–2011 influenza season. Both influenza and routine childhood immunization studies, prior to the 2008 ACIP influenza recommendations expansion, found that private, not public, providers had higher vaccination rates.[8–13] Specifically, Santibanez et al.[8] found higher

Table 2. Predictors of pediatric influenza vaccination, 2010–2011 season[a]

Variable	Model 1: unadjusted OR (95% CI) (*n*=2,373,826)	Model 2: AOR (95% CI)[b] (*n*=1,850,969)	Model 3: interaction OR (95% CI)[c] (*n*=1,850,969)
Provider point of contact			
Public	0.60 (0.60, 0.61)	0.87 (0.86, 0.88)	—
Private	ref	ref	
Age group			
6–23 months		1.25 (1.23, 1.27)	—
24–59 months		0.85 (0.84, 0.86)	—
5–12 years		1.04 (1.03, 1.05)	—
13–17 years		ref	
Immunization provider visit in past 12 months			
Yes		3.31 (3.28, 3.34)	3.31 (3.28, 3.34)
No		ref	ref
Vaccine funding source			
VFC		0.76 (0.75, 0.77)	0.76 (0.75, 0.77)
Private/self		ref	ref
Other		1.07 (1.03, 1.11)	1.07 (1.03, 1.10)
Median household income[d]		0.92 (0.81, 1.05)	0.92 (0.81, 1.05)
Families below poverty line, %[e]		0.65 (0.45, 0.93)	0.65 (0.45, 0.93)
Black race, %[e]		0.93 (0.82, 1.06)	0.93 (0.82, 1.06)
Public versus private (interaction term, $p<.0001$)			
6–23 months			0.87 (0.85, 0.90)
24–59 months			0.86 (0.84, 0.88)
5–12 years			0.86 (0.84, 0.87)
13–17 years			0.91 (0.89, 0.93)

[a]GLMM with a random intercept for county was used for the association between provider point of contact and influenza vaccination.
[b]Adjusted for categorical age, immunization provider visit in the past 12 months, vaccine funding source, median household income, percentage of families living below the poverty line, and percentage of county residents of black race.
[c]Adjusted for immunization provider visit in past 12 months, vaccine funding source, median household income, percentage of families living below the poverty line, and percentage of county residents of black race.
[d]A one-unit increase is equivalent to a $10,000 change in median household income.
[e]A one-unit increase is equivalent to a 10% change.
GLMM, Generalized linear mixed model; VFC, Vaccines for Children

influenza vaccination rates for private compared to public providers for children aged 6–23 months during the 2002–2003 and 2003–2004 influenza seasons using National Immunization Survey data.

Several studies[7,17–20] have attributed lower SES and fewer interactions with a healthcare provider as reasons why children miss out on influenza and routine childhood vaccinations. A greater percentage of the children receiving care at health departments have been noted to be VFC-eligible,[21] which could help explain the finding of lower influenza vaccination rates among children receiving care from public compared to private providers. Regardless of the provider type, children visiting an immunization provider in the past 12 months had a greater likelihood of being vaccinated against influenza.

The county-level factors examined were not shown to be confounders in the association between provider type and influenza vaccination. Inclusion of county-level factors in the models was intended to elucidate the association between provider type and influenza vaccination by helping explain differences in underlying factors such as access to healthcare services, attitudes and beliefs on the healthcare system and vaccination, or adequacy of medical care.[22,23] Instead, county-level factors may be poor proxies for these factors.

Although inclusion of county factors in the models did not clarify the association between provider type and influenza vaccination, a 10% increase in the percentage of families living below the poverty line decreased the odds of vaccination by 35% in the adjusted model. County characteristics have been used to describe disease occurrence and routine childhood vaccination in previous studies,[14,15] but this is the first study showing county-level factors associated with influenza vaccination.

In the age–provider interaction, children in all age groups, 6–23 months, 24–59 months, 5–12 years, and 13–17 years, had the same public–private provider disparity of decreased likelihood of influenza vaccination. Because the ORs were similar for children in the four age groups, these findings may indicate parental perception that influenza risk does not change with age despite the public health messaging that younger children are at increased risk of influenza.[22,24]

Influenza vaccination coverage differed by age in the descriptive data and adjusted model, which is likely due to the number of provider visits of young children but could partly be explained by the time elapsed since expansion of influenza vaccine recommendations. Regardless of the underlying reasons, influenza vaccination rates were low for all age groups. Strategies aimed at improving vaccination coverage, like reducing out-of-pocket cost and increasing provider usage of reminder-recall systems, has the potential to increase influenza vaccination rates for children of all age groups.

The study was subject to several limitations. First, for this study period, MCIR data relied on immunization provider voluntary reporting of influenza vaccination. Under-reporting of influenza vaccination is a problem because influenza vaccines were not required to be reported to MCIR, with the exception of VFC providers who are required under Michigan's implementation of the VFC program. Under-reporting of influenza vaccination is estimated to be 50% for non-VFC providers.

The analysis used MCIR to determine vaccination status and if a child had no record of vaccination or if a child was incompletely vaccinated, the child was considered unvaccinated. This overestimated the number of unvaccinated children. The misclassification of influenza vaccinations would likely manifest as higher vaccination rates for public providers because VFC enrollment is more common in this group. Despite this, public providers had lower influenza vaccination rates.

The complexity of the algorithm to determine which children needed two doses of vaccine in the 2010–2011 season also contributed to the number of unvaccinated children because of the immunization provider's understanding of the recommendations and reliance on incomplete parental vaccination histories.

A second limitation is that the data quality in MCIR on young children is good but decreases with child's age. The MCIR participates as a CDC immunization information sentinel site because of its comprehensiveness and high data quality, with 97 million immunization records on 8 million individuals. Michigan is one of only 22 states that attained $\geq$95% participation of children aged $<$6 years during 2011.[25] Owing to movement in and out of Michigan and compounded by the decreasing well child visits over time, the findings of older children may be less generalizable than those of younger children who see healthcare providers for well child checkups.

A final limitation was the inability to include unmeasured confounders. At the individual level, no data exist to incorporate stressors such as single-parent households and flexibility in time off from work, parental education, and vaccination attitudes and beliefs, and the analysis of mother's race was limited to children aged $<$5 years. For the immunization providers, information was lacking on provider location, patient volume, and the use of expanded vaccination strategies, which are factors that have been associated with influenza vaccination rates in children.[7] Unmeasured county factors included immunization provider concentration, penetration of vaccine messaging, and other socioeconomic factors.[26]

In conclusion, provider type influences whether a child is vaccinated against influenza in Michigan, as children with public providers are less likely to receive influenza vaccines compared to private providers. County factors were not shown to confound the association between immunization providers and influenza vaccination, although the percentage of families living below the poverty line was negatively associated with influenza vaccination. Child's age did not meaningfully modify the receipt of influenza vaccination by provider type despite a statistically significant interaction. The current findings underscore the need for more effective strategies to improve influenza vaccination rates for all Michigan children and the need to consider the community's impact on vaccinations.

The Michigan Department of Community Health, Division of Immunizations, supported this study. Funding support for Dr. Clayton was provided through the Rackham Merit Fellowship at the University of Michigan.

No financial disclosures were reported by the authors of this paper.

References

1. CDC. Prevention and control of influenza with vaccines: recommendations of the Advisory Committee on Immunization Practices (ACIP), 2010. MMWR Recomm Rep 2010;59(RR-8):1–62.
2. CDC. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices (ACIP), 2008. MMWR Recomm Rep 2008;57(RR-7):1–60.
3. CDC. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2004;53(RR-6):1–40.
4. CDC. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2006;55(RR-10):1–42.
5. CDC. Use of influenza A (H1N1) 2009 monovalent vaccine: recommendations of the Advisory Committee on Immunization Practices (ACIP), 2009. MMWR Recomm Rep 2009;58(RR-10):1–8.

6. CDC. Influenza vaccination coverage, 2010–2011 influenza season. cdc.gov/flu/professionals/vaccination/reporti1011/reportI/.
7. Poehling KA, Fairbrother G, Zhu Y, et al. Practice and child characteristics associated with influenza vaccine uptake in young children. Pediatrics 2010;126(4):665–73.
8. Santibanez TA, Santoli JM, Bridges CB, Euler GL. Influenza vaccination coverage of children aged 6 to 23 months: the 2002–2003 and 2003–2004 influenza seasons. Pediatrics 2006;118(3):1167–75.
9. Groom H, Kolasa M, Wooten K, Ching P, Shefer A. Childhood immunization coverage by provider type. J Public Health Manag Pract 2007;13(6):584–9.
10. Morrow AL, Rosenthal J, Lakkis HD, et al. A population-based study of access to immunization among urban Virginia children served by public, private, and military health care systems. Pediatrics 1998;101(2):1–10.
11. Mennito S, Darden P. Impact of practice policies on pediatric immunization rates. J Pediatr 2010;156(4):618–22.
12. Zhao Z, Luman E. Progress toward eliminating disparities in vaccination coverage among U.S. children, 2000–2008. Am J Prev Med 2010;38(2):127–37.
13. Rosenthal J, Rodewald L, McCauley M, et al. Immunization coverage levels among 19- to 35-month-old children in 4 diverse, medically underserved areas of the U.S. Pediatrics 2004;113(4):e296–e302.
14. Lifson AR, Roddy M, Ehresmann KR. The association of poverty and low immunization rates in ZIP code areas: a retrospective survey of Minnesota kindergartners. Minn Med 2000;83(8):51–5.
15. CDC. County-level trends in vaccination coverage among children aged 19–35 months—U.S., 1995–2008. MMWR Surveill Summ 2011;60(SS-4):1–86.
16. Michigan Compiled Laws, §333.9207 (2006).
17. Fairbrother G, Friedman S, DuMont KA, Lobach KS. Markers for primary care: missed opportunities to immunize and screen for lead and tuberculosis by private physicians serving large numbers of inner-city Medicaid-eligible children. Pediatrics 1996;9(6):785–90.
18. Allred NJ, Poehling KA, Szilagyi PG, et al. The impact of missed opportunities on seasonal influenza vaccination coverage for healthy young children. J Public Health Manag Pract 2011;17(6):560–4.
19. Bardenheier BH, Yusuf HR, Rosenthal J, et al. Factors associated with underimmunization at 3 months of age in four medically underserved areas. Public Health Rep 2004;119(5):479–85.
20. Luman ET, McCauley M, Stokley S, Chu SY, Pickering LK. Timeliness of childhood immunizations. Pediatrics 2002;110(5):935–9.
21. Santoli JM, Barker LE, Lyons BH, et al. Health department clinics as pediatric immunization providers: a national survey. Am J Prev Med 2001;20(4):266–71.
22. Nowalk MP, Zimmerman RK, Lin CJ, et al. Parental perspectives on influenza immunization of children aged 6 to 23 months. Am J Prev Med 2005;29(3):210–4.
23. Bhat-Schelbert K, Lin CJ, Matambanadzo A, et al. Barriers to and facilitators of child influenza vaccine—perspectives from parents, teens, marketing and healthcare professionals. Vaccine 2012;30(14):2448–52.
24. CDC. National Center for Immunization and Respiratory Diseases (NCIRD). cdc.gov/ncird.
25. CDC. Progress in immunization systems—U.S., 2011. MMWR Morb Mortal Wkly Rep 2013;62(3):48–51.
26. Fu LY, Cowan N, McLaren R, Engstrom R, Teach SJ. Spatial accessibility to providers and vaccination compliance among children with Medicaid. Pediatrics 2009;124(6):1579–86.