



Published in final edited form as:
NC Med J. 2013 ; 74(3): 185–191.

Verifying Influenza and Pneumococcal Immunization Status of Children in 2009–2010 from Primary Care Practices and from the North Carolina Immunization Registry

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Abstract

Background—The North Carolina Immunization Registry (NCIR) has been available since 2004. We sought to measure its utilization among practices providing primary care for children enrolled in a prospective influenza surveillance study.

Methods—Eligible children 0.5–17 years of age presented to an emergency department or inpatient setting with fever/acute respiratory symptoms in Winston-Salem, NC from September 2009 until May 2010. Study team members verified child influenza and pneumococcal immunization status by requesting records from the primary care practice and independently by reviewing the NCIR. We assessed agreement of non-registry immunization medical records with NCIR data using the Kappa statistic.

Results—A total of 221 (98%) of 226 enrolled children <6 years of age had 2 immunizations documented in the registry. Fifty-six practices confirmed the immunization status for 292 study enrolled children. For most study children (238/292, 82%), practices verified their immunizations with a NCIR record. For 54 children whose practices verified their immunizations by providing practice records alone, agreement with the NCIR by the Kappa statistic was 0.6–0.7 for seasonal and monovalent H1N1 influenza vaccines and 0.8–0.9 for pneumococcal conjugate and polysaccharide vaccines.

Limitations—NCIR usage may vary in other regions of NC.

Conclusion—NCIR was commonly used for study children. More than 95% of children <6 years of age had 2 immunizations documented in the NCIR, achieving the Centers for Disease Control and Prevention 2010 goal. We found substantial agreement between practice records and NCIR records for influenza and pneumococcal immunizations in children.

Keywords

influenza vaccine; immunization registry; pneumococcal conjugate vaccine; pneumococcal polysaccharide vaccine; monovalent H1N1 vaccine

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Disclosure: This study was supported in part by the National Institute of Allergy and Infectious Diseases (R01 AI79226) and by the Wachovia Research Fund. The views expressed in this article are solely those of the authors and do not necessarily represent the official views of the National Institute of Allergy and Infectious Diseases or the U.S. government.

Potential conflicts of interest. All authors (K.A.P, L.V, and T.R.P.) have received research support from BD Diagnostics (Sparks, MD).

Childhood immunization schedules have expanded over the past decade for children of all ages, including young children and adolescents [1, 2]. Children frequently obtain vaccines from multiple sources. Many children receive their first dose of hepatitis B vaccine during the birth hospitalization [3, 4], and some children receive immunizations from multiple providers [5]. To minimize the dispersal of immunization records, state-based immunization registries have been recommended by the U.S. Centers for Disease Control and Prevention [6]. North Carolina modified the Wisconsin Immunization Registry to develop the North Carolina Immunization Registry (NCIR), a secure, population-based and web-based clinical tool implemented in 2004 [7]. This study measured 1) the extent to which providers used the NCIR in 2009–2010 and 2) the agreement between practice-based and registry-based records for influenza and pneumococcal immunizations among children.

Methods

Children were prospectively enrolled in an influenza surveillance study if they presented with acute respiratory illness or fever to an emergency department or inpatient settings in one of two hospitals in Winston-Salem, NC, including the region's only children's hospital, from September 1, 2009 through May 19, 2010. Eligible children resided in Forsyth County or one of its seven contiguous NC counties. After informed consent from parent/guardian and child assent, when appropriate, children were enrolled and permission was obtained to verify their influenza and pneumococcal immunization history by contacting their primary care practice and by reviewing the NCIR. This study is distinct from our previous study comparing parental report for 2009–2010 influenza vaccine to any confirmation from NCIR or practice report during the H1N1 influenza pandemic ending mid-April 2012 [8].

In the spring and summer of 2010, a facsimile was sent to the parent-identified, primary care practice and requested verification of the influenza and pneumococcal immunization status for each enrolled child. Influenza and pneumococcal immunization status were independently verified in the NCIR.

Study Population

The study population comprised all children who were prospectively enrolled, had immunizations entered into the NCIR, and had their influenza and pneumococcal immunization status verified by a practice.

Influenza Immunization Status

In 2009–2010, influenza vaccine recommendations for seasonal and H1N1 monovalent influenza vaccine differed, particularly for children 9 years of age [9–11]. The definitions of fully, partially and not immunized for each vaccine are shown in Table 1.

Agreement between the Practice-based and Registry-based Records

Many practices responded to our request for immunization verification by providing a copy of the NCIR record. The expected agreement between the practice copy of the NCIR and our review of this registry record should approximate 100%. Hence, we limited the assessment of agreement to children whose practice verified the immunization status using practice records alone. Because influenza vaccine was recommended for children 6 months of age, the study population comprised children 0.5 through 17 years of age. For these children, we compared the doses of seasonal and H1N1 monovalent influenza vaccines in 2009–2010 and the doses of pneumococcal conjugate vaccine (7-valent or 13-valent) or any pneumococcal polysaccharide vaccine from the practice-based record to that recorded in the NCIR. Because 23-valent pneumococcal polysaccharide vaccine is recommended for children 2 years of age with medical conditions predisposing to pneumococcal disease, we limited this

vaccine assessment to children 2–17 years of age [12]. For each vaccine, the number of doses from practice-based and registry-based records was compared to compute the percent agreement, expected percent agreement, and a simple (not weighted) Kappa statistic (K) with its p-value. The κ , a measure of inter-rater agreement that accounts for the likelihood that the observed agreement could occur by chance, may range from -1 (perfect disagreement beyond chance) to $+1$ (perfect agreement beyond chance). According to the categorization scheme from Landis and Koch, a κ of >0.81 has almost perfect agreement, a κ of 0.61 – 0.80 has substantial agreement, and a κ of 0.41 – 0.6 has moderate agreement [13]. We also computed the sensitivity, specificity, positive predictive value and negative predictive value with each child for each vaccine being classified as any or no immunization from the NCIR record as compared to that from practice-based records. Exact 95% confidence intervals were computed using the binomial distribution. All analyses were performed using STATA 8.1 (College Station, TX).

This study was approved by the Wake Forest School of Medicine Institutional Review Board with written parental consent and child assent when appropriate and by an authorization agreement between the institutional review boards of Forsyth Medical Center and Wake Forest School of Medicine.

Results

The study population comprised 292 (87%) of 334 children enrolled from September 1, 2009 through May 19, 2012 who had influenza and pneumococcal immunizations verified from both the registry and the practice (Figure 1). Over three-quarters of study children were <9 years of age, approximately half were male, half were black, and three quarters resided in Forsyth County (Table 2). More parents reported that their child obtained care from pediatric practices (76%) than from family medicine practices (19%) or health departments (6%).

For 238 (82%) study children, the practices verified the immunizations with NCIR record. Children whose practice provided verification with practice-based records only were younger, less likely to be non-Hispanic white, more likely to reside in a county surrounding Forsyth County, and more likely to obtain care at a family medicine practice than children whose practices sent the NCIR record (Table 2). A total of 221 (98%) of all 226 children <6 years of age had a NCIR record with 2 immunizations documented.

Parents reported that these 292 children were seen in one of 56 practices, of which 30 (54%) were pediatric practices, 21 (34%) were family medicine practices and 5 (11%) were health departments. The mean number of enrolled children per practice was 8 (range 1 to 60) for pediatric practices, 3 (range 1 to 12) for family medicine practices, and 2 (range 1 to 4) for health departments.

Primary care practices administered the majority of seasonal and monovalent H1N1 influenza vaccine in 2009–2010 in this study. Among 182 verified doses of seasonal influenza vaccine, 85% were administered in the primary practice, 10% in a health department, 3% in another practice, and 2% in school or wellness center. Among 118 verified doses of monovalent H1N1 influenza vaccine, 75% were administered in the primary practice, 17% in a health department, 6% in school or wellness center, and 3% in another practice. The NCIR confirmed 172 (94.5%) of 182 verified doses of seasonal influenza vaccine and 115 (97%) of 118 verified doses of monovalent H1N1 influenza vaccine in 2009–2010.

For 54 children whose practices verified their immunization status with practice records only, we ascertained the agreement between the practice records and the NCIR. The Kappa

statistic was lower for 2009–2010 seasonal and H1N1 influenza vaccines ($\kappa=0.63$ and $\kappa=0.71$, Table 3) than for pneumococcal conjugate and 23-valent pneumococcal polysaccharide vaccines ($\kappa=0.92$ and $\kappa=0.84$, Table 3).

The primary reason for the discrepancy between the practice report and the NCIR differed for influenza and pneumococcal vaccines. Two different practices reported one dose of seasonal influenza vaccine and one dose of H1N1 monovalent influenza vaccine that was not entered into the NCIR, negatively impacted the sensitivity and negative predictive value of the influenza immunization status from the registry (Table 4). Conversely, one child had pneumococcal conjugate vaccine and another child had pneumococcal polysaccharide vaccine reported by the practice in the NCIR (per our review) but not recorded in the practice-provided verification. This discrepancy negatively impacted the specificity and positive predictive value of the pneumococcal immunization status from the registry.

Discussion

This study demonstrated that the NCIR was commonly used in 2009–2010 by practices in Forsyth County and its seven contiguous counties. Primary care practices provided immunization verification in the form of the NCIR record for most (82%) enrolled children. Further, 221 (98%) of all 226 enrolled children <6 years of age had a NCIR record with 2 immunizations recorded. Thus, in this study population the NCIR was frequently used and achieved the 2010 goal from the U.S. Centers of Disease Control and Prevention that at least 95% of children <6 years of age have 2 recorded immunizations [6].

For children whose practice did not verify immunization records with the NCIR record, we found substantial agreement between practice and NCIR records (Kappa statistic of 0.63) for seasonal and monovalent H1N1 influenza vaccines and almost perfect agreement (Kappa statistic of 0.84) for pneumococcal conjugate and polysaccharide vaccines per the categorization scheme by Landis and Koch [13]. Hence, there was high concordance for influenza and pneumococcal immunizations between the practice records and the NCIR even when the practice did not verify the immunizations with the registry.

We believe that the practices included in this study reflect the practices serving Forsyth and its seven contiguous counties in North Carolina. Among enrolled children, 76% received primary care at a pediatric practice and is similar to 77% of well-child visits among children 0–18 years to general pediatricians according to an analysis of data from 2004–2007 National Ambulatory Medical Care Survey [14].

Our results are comparable to previous reports for other U.S. immunization registries. We found 98% of children 0.5–<6 years of age had a NCIR record with 2 immunizations documented within 6 years of the registry being implement. This result is similar to the report that 92% of children 19–35 months were included in the KIDS Immunization Registry in Philadelphia, PA and that 91% of children <5 years were included in the Arizona State Immunization Information System [15, 16]. Also, we found that 94.5% of verified doses of seasonal influenza vaccine and 97% of doses of monovalent H1N1 influenza vaccine were reported in the NCIR, similar to the 95% capture of all influenza immunizations in 2006–2008 by a regional immunization registry in Wisconsin [17].

In 2009–2010, the NCIR required direct data entry by medical practice personnel, such that information flow occurred in one direction. NCIR is working towards developing bi-directional communication between its immunization registry and electronic health records that achieves design principles of Health Level 7 Standards [7, 18]. Bi-directional communication is expected to increase the proportion of all North Carolina children entered into the registry. Financial incentives for adopting electronic health records and their

“meaningful use” should significantly enhance the adoption of electronic health records in primary practice settings throughout North Carolina. Once bi-directional communication is well-established, the use of NCIR for all persons, including adults, may increase and is potentially important given expansion of the adult immunization schedule since 2002 [19, 20].

This study has several limitations. Study children resided in Forsyth County and its seven contiguous counties and thus may not reflect immunization registry usage throughout the state; however these counties include urban, suburban and rural populations, reflecting the metropolitan diversity within North Carolina. The few children that did not have an entry in the NCIR or whose practice did not verify their immunizations could have systematically differed from study children who had their immunizations verified in both sources. Children were enrolled in the emergency department and inpatient setting and thus may systematically differ from children who did not have an emergency department visit or hospitalization; yet, being able to verify the immunization status of children presenting to the ED or inpatient setting is important. We may have underestimated the immunization status of children if they received influenza or pneumococcal vaccine at another practice or another location that did not enter the data in the NCIR. For example, pharmacists were granted temporary authorization to administer seasonal and monovalent influenza vaccines to children 14 years of age from October 9, 2009 through July 2010 [21]. Also, this project focused on influenza and pneumococcal vaccines and not all recommended pediatric vaccines, and results for up-to-date immunization registry utilization may vary.

In summary, the NCIR was widely used for children residing in Forsyth County, NC and its seven contiguous counties. There was substantial agreement between practice-based and registry-based records for influenza and pneumococcal vaccines. The NCIR is a valuable resource in the effort to defend the public health through control of vaccine-preventable diseases.

Acknowledgments

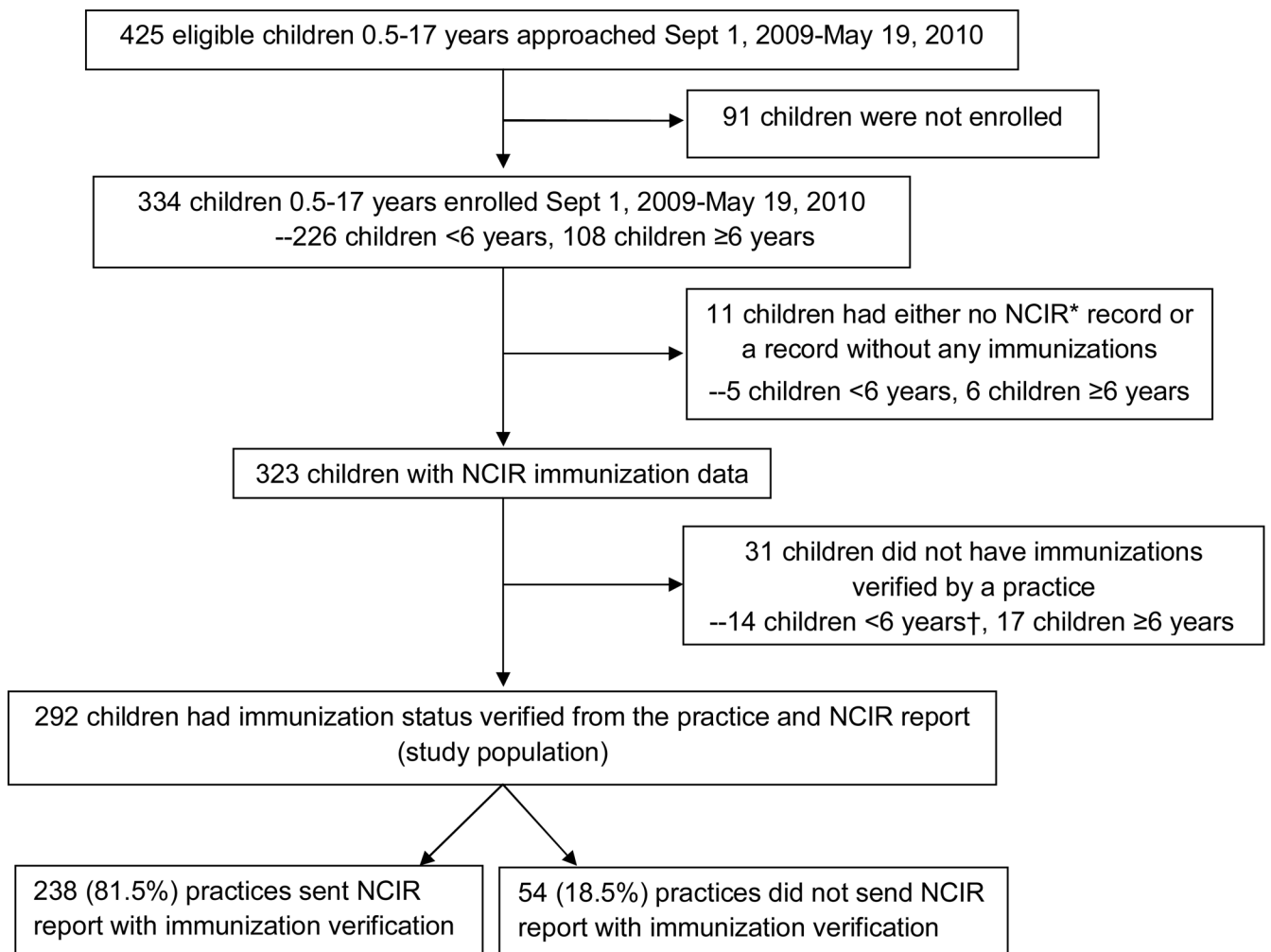
We thank all the participating children and their families as well as their practices and health departments who made this study possible. We thank the anonymous reviewers whose comments and suggestions enhanced this manuscript.

Financial support: This work was supported by the National Institute of Allergy and Infectious Disease (R01 AI079226) and Wachovia Research Fund. The views expressed in this article are solely those of the authors and do not necessarily represent the official views of the National Institute of Allergy and Infectious Diseases or the U.S. government.

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**Figure 1.**

Derivation of the Study Population

*NCIR is North Carolina Immunization Registry.

† These 14 children <6 years of age had 2 immunizations recorded in NCIR.

Table 1

Immunization status definitions for the 2009–2010 seasonal and H1N1 monovalent influenza vaccines [9–11]

Immunization status	Age group	Definition
2009–2010 seasonal influenza vaccine		
Fully immunized	0.5–<9 years	2 doses if not fully immunized in a previous season
	0.5–<9 years	1 dose if fully immunized in a previous season
	9 years	1 dose
Partially immunized	0.5–<9 years	1 dose and not fully immunized in a previous season
Not immunized	0.5–18 years	0 doses
2009–2010 H1N1 monovalent influenza vaccine		
Fully immunized	0.5–<10 years	2 doses
	10 years	1 dose
Partially immunized	0.5–<9 years	1 of 2 recommended doses
Not immunized	0.5–18 years	0 doses

Table 2

Demographic Characteristics and Vaccination Status of Study Children

	Registry from practice		p-value
	Yes	No	
	N=238	N=54	
Characteristics	N (col %)	N (col %)	
Age Group			0.04
0.5–<2 years	82 (34%)	15 (28%)	
2–5 years	95 (40%)	15 (28%)	
6–8 years	29 (12%)	15 (28%)	
9–17 years	32 (16%)	9 (17%)	
Gender			0.34
Male	123 (52%)	24 (44%)	
Female	115 (48%)	30 (56%)	
Race			0.03
White	56 (24%)	7 (13%)	
Black	132 (56%)	27 (50%)	
Other	50 (21%)	20 (37%)	
County Residence			0.001
Forsyth County	196 (82%)	32 (59%)	
1 of 7 Contiguous Counties	42 (18%)	20 (41%)	
Practice type			<0.001
Pediatric	200 (84%)	28 (52%)	
Family Practice	29 (12%)	24 (44%)	
Health Department	9 (4%)	2 (4%)	
Seasonal influenza vaccine			0.85
None	123 (52%)	27 (50%)	
Partially immunized	40 (17%)	8 (15%)	
Fully immunized	19 (35%)	75 (32%)	
H1N1 influenza vaccine			0.15
None	168 (71%)	40 (74%)	
Partially immunized	40 (17%)	4 (7%)	
Fully immunized	30 (13%)	10 (19%)	
Pneumococcal conjugate vaccine(s)*			0.54
None	25 (11%)	6 (11%)	
1 dose	7 (3%)	4 (7%)	
2 doses	12 (5%)	2 (4%)	
3 doses	48 (20%)	7 (13%)	
4 doses	145 (61%)	35 (65%)	
5 doses	1 (<1%)	0 (0%)	

	Registry from practice		p-value
	Yes	No	
	N=238	N=54	
Characteristics	N (col %)	N (col %)	
Pneumococcal polysaccharide vaccine[†]			0.12
None	150 (96%)	35 (90%)	
Any dose(s)	6 (2%)	4 (10%)	

Sum of percents may exceed 100% due to rounding error.

* 7-valent and/or 13-valent pneumococcal conjugate vaccine. Children <5 years of age who had received 4 doses of 7-valent pneumococcal conjugate vaccine were recommended to receive 1 dose of 13-valent pneumococcal conjugate vaccine.

[†] 23-valent pneumococcal polysaccharide vaccine data is limited to children 2–17 years of age.

Table 3

Agreement between North Carolina Immunization Registry-based and practice-based influenza and pneumococcal immunization records

Doses per registry record	Doses per practice records			Agreement	Expected agreement	Kappa statistic		
Seasonal influenza vaccine, N=54*								
	None	1 dose	2 doses	80%	45%	0.63 [‡]		
None	27	7	1					
1 dose	2	11	1					
2 doses	0	0	5					
Monovalent H1N1 influenza vaccine, N=54*								
	None	1 dose	2 doses	89%	62%	0.71 [‡]		
None	40	1	0					
1 dose	0	3	2					
2 doses	2	1	5					
Pneumococcal conjugate vaccine, N=54*								
	None	1	2	3	4	96%	54%	0.92 [‡]
None	6	0	0	0	0			
1 dose	0	2	0	0	1			
2 doses	0	0	2	0	0			
3 doses	0	0	0	4	1			
4 doses	0	0	0	0	38			
23-valent pneumococcal polysaccharide vaccine, N=39[‡]								
	None	1 dose						
None	35	0			97%	84%	0.84 [‡]	
1 dose	1	3						

* Data for children 0.5–17 years of age.

[‡]Data for children 2–17 years of age since 23-valent pneumococcal vaccine is not recommended for any children <2 years of age.

[‡]The p-value was <0.001.

Characterization of influenza and pneumococcal immunizations in 2009–2010 from the North Carolina Immunization Registry as compared to practice-based records

Table 4

Registry-based	Practice-based		Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
	Immunized	Not immunized				
Seasonal influenza vaccine, N=54*						
Immunized	17	2	68%	93%	89%	77%
Not immunized	8	27	(46–85%)	(77–99%)	(67–99%)	(60–90%)
H1N1 monovalent influenza vaccine, N=54*						
Immunized	11	2	92%	95%	85%	98%
Not immunized	1	40	(62–99.8%)	(84–99%)	(55–98%)	(87–99.9%)
Pneumococcal conjugate vaccines, N=54*						
Immunized	48	0	100%	100%	100%	100%
Not immunized	0	6	(93–100%) [‡]	(54–100%) [‡]	(54–100%) [‡]	(93–100%) [‡]
23-valent pneumococcal polysaccharide vaccine, N=39[‡]						
Immunized	3	1	100%	97%	75%	100%
Not immunized	0	35	(29–100%) [‡]	(85–99.9%)	(19–99%)	(90–100%) [‡]

* Data for children 0.5–17 years of age.

[‡] Data for children 2–17 years of age since 23-valent pneumococcal vaccine is not recommended for any children <2 years of age.

[‡] One-sided exact 97.5% confidence interval using binomial distribution.