A Pilot Program to Improve Vaccination Status for Hospitalized Children

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KEY WORDS
immunization, vaccination, inpatient, hospitalized

ABBREVIATIONS
ACIP: Advisory Committee on Immunization Practices
CDC: Centers for Disease Control and Prevention
FTE: full-time equivalent
HPV: human papilloma virus
PCP: primary care provider
VZV: varicella zoster vaccine

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abstract

OBJECTIVES: Screening of immunization status at each health care encounter is recommended to improve immunization coverage rates but is often limited to primary care practices. A pilot intervention study was performed to ascertain the immunization status of hospitalized children and determine if development of an immunization plan before discharge would improve the vaccination status for such children.

METHODS: On the basis of power calculations estimated to detect an increase in immunization status from 60% to 70% with 80% power, 356 randomly selected children were enrolled between March 6, 2012 and June 14, 2012. Immunization records were obtained, immunization status determined, and parent/guardian informed if catch-up dose(s) were needed. If parent requested vaccine dose(s), they were administered before discharge.

RESULTS: Vaccination status was current per Advisory Committee on Immunization Practices guidelines in 73% of hospitalized children, and 27% children required catch-up dose(s) (200 doses for 95 children). Human papilloma virus vaccine (dose 1), varicella zoster vaccine (dose 2), and meningococcal conjugate vaccine were the most commonly identified dose(s) needed. Of those requiring catch-up dose(s), 25% were caught up, increasing vaccination status to 80% at 1-month post hospital discharge.

CONCLUSIONS: This is the first study to determine the immunization status of hospitalized pediatric patients of all ages, including adolescents, providing new data on the immunization status of the inpatient pediatric population. A pilot intervention consisting of obtaining immunization records, determining immunization status, and discussing catch-up dose(s) before discharge resulted in improvement of immunization status, suggesting that the inpatient setting may be used along with many other national strategies to help address missed vaccination opportunities.

Vaccines are considered to be among the most cost-effective preventive services and the greatest public health achievements. Federal vaccine guidelines, supported by the American Academy of Pediatrics and the American Academy of Family Practice, are generated every year by the Advisory Committee on Immunization Practices (ACIP) of the Centers for Disease Control and Prevention (CDC). Despite established guidelines, vaccination rates remain suboptimal. The consequences are palpable, with reemergence of vaccine preventable diseases in the United States and deaths that could have potentially been prevented.[1–4] Studies have identified multiple barriers to vaccination, including parental concern

regarding potential adverse effects associated with vaccinations, distrust of the medical community, problems with access to vaccinations (transportation, financial, and organizational), being unaware of the vaccination schedule, long wait times, and perception that providers rush through encounters.[5,6]

Hospitalized children are reported to have lower immunization rates than the general population,[7] with some studies showing that as many as half of hospitalized children are "not current" or underimmunized.[8] The data regarding immunization status of hospitalized children in the United States, however, is scarce and outdated. Immunization status screening is rarely done routinely outside of primary care facilities, or when it is done (mostly by asking parents), it is often inaccurate.[9–11] A key barrier to ascertaining the immunization status of children outside the medical home or primary care setting is lack of access to immunization records. Additionally, high-risk, frequently hospitalized patients are underimmunized because of perceived contraindications or lack of access to convenient primary care despite parental willingness to vaccinate.[12] Our objectives were (1) to determine the immunization status of our inpatient population and (2) to evaluate the effectiveness of a pilot intervention to increase the immunization status of hospitalized children as per ACIP guidelines.

METHODS

This pilot study was conducted at a 350-bed freestanding children's hospital in Kansas City, MO. All hospitalized children <18 years of age admitted on business days (Monday through Friday) were eligible to participate in the study. Patients who were immunocompromised or required critical care were excluded because of different immunization requirements compared with healthy children and concerns about approaching families at a critical time. In addition, patients admitted for short stay of <24 hours were also excluded because of the difficulty in obtaining the records and consenting patients in such a short time frame. A 0.5 full-time equivalent (FTE) level 1 research coordinator performed all activities related to this pilot project, including review of daily admissions, screening patients, tracking immunizations records, determining immunization status, informing patients and parents/legal guardians of immunizations needed, and performing follow-up phone calls.

On the basis of literature reviews, we estimated the baseline immunization status of the inpatient pediatric population to be ~60%.[7,8] Through power calculations, we determined a sample size of 356 participants gave us 80% power to detect an increase in immunization status from 60% at admission to 70% at 1-month follow-up. Between March 6, 2012 and June 14, 2012, we used a random sequence generator (www.random.org) to select 5 daily eligible hospitalized children on business days Monday through Friday out of all eligible daily admissions until we reached our target of 356. Baseline demographics including age, gender, race, and insurance type were collected from the medical record. Patients' parents/legal guardians were asked to report if they had a primary care provider (PCP), and we confirmed PCPs' contact information for follow-up. We obtained immunization records from all potential sources, including parents/legal guardians, current and previous PCPs, schools, state immunization registries, and hospital of birth. After all immunization records were obtained, the child's vaccination status was determined per ACIP guidelines via the CDC's free online scheduler (under Interactive Tools online at: http://www.cdc.gov/vaccines/schedules/hcp/child-adolescent.html). This online tool was designed by the CDC to help parents and health care providers determine the vaccines a child or teenager needs, especially missed or skipped vaccines. This tool simplifies the process, and, most important, makes a standardized decision on immunization status as per ACIP guidelines. Influenza vaccination was not considered in determining vaccination status because the study was conducted outside of influenza season. If the child's immunization status was determined to be current per ACIP guidelines, no further action was required. For children needing catch-up doses per ACIP guidelines, a personalized vaccine plan was created. The interpretation of rules for creating a catch-up vaccination schedule are complex and may vary from provider to provider, thus we used the vaccine plan provided by the online scheduler described earlier. The parents/legal guardians were then informed of the dose(s) needed. In some cases, parents would report dose had been given (for example, at a different location because of travel) or was avoided for a medical reason (for example, a child who did not have varicella zoster vaccine [VZV] because of a history of natural infection). In those cases, we contacted the PCP or additional source reported by parent, and if information was confirmed, we adjusted immunization status accordingly. If the parents requested the vaccine

dose(s) while the child was hospitalized, the inpatient team was contacted and the dose(s) were administered before discharge. Otherwise, the dose(s) needed were added to the discharge summary and sent to the PCPs and home with the family members. The PCP was contacted 1 month after hospital discharge to inquire if recommended dose(s) were administered. A process map describing steps taken by the research coordinator (0.5 FTE) can be seen in Fig 1. We compared immunization status recorded at admission to immunization status 1 month after discharge using McNemar's test with a 1-sided significance level of .05. χ^2 tests with a 2-sided significance level of .05 were used to look for group differences.

RESULTS

There were 3994 children hospitalized between March 6, 2012 and June 14, 2012; 843 were eligible to participate in our study, and we enrolled 356 randomly selected children per our study protocol. The median age was 5 years (interquartile range 1.3–9.7), 52% were boys with predominantly public (50%) or private (40%) insurance. The majority of participants' self reported race/ethnicity as determined from the medical record was white (62%), followed by African American (17%) and Hispanic (8%; Table 1).

Immunization records were obtained from various sources including PCPs (47%), public health departments (23%), electronic medical records (19%), parents (3%), or other/combinations of these (8%). Vaccination status was determined to be current per ACIP guidelines in 261 (73%) of the 356 children at admission. At 1-month follow-up, the percentage of children current per ACIP recommendations showed a statistically significant increase from 73% at admission to 80% ($P < .001$).

We divided our cohort into 4 age groups: 0 to 23 months (118, 33.1%), 2 to 6 years (101, 28.4%), 7 to 10 years (65, 18.2%), and >11 years (72, 20%). Children ≥11 years were least likely to meet ACIP guidelines at baseline but were also most likely to receive catch-up dose(s) at 1-month follow-up compared with all other age groups ($P < .001$; Fig 2). Children aged 2 to 6 years also saw a significant increase in the percentage meeting ACIP guidelines, going from 76% at baseline to 83% at 1-month follow-up ($P < .01$). Children in the other 2 age groups had nonsignificant increases in up-to-date vaccination status.

The 95 children (27%) found to be underimmunized per ACIP recommendations required a combined total of 200 catch-up doses, including human papilloma virus (HPV) vaccine; VZV; meningococcal conjugate vaccine; hepatitis A vaccine; inactivated

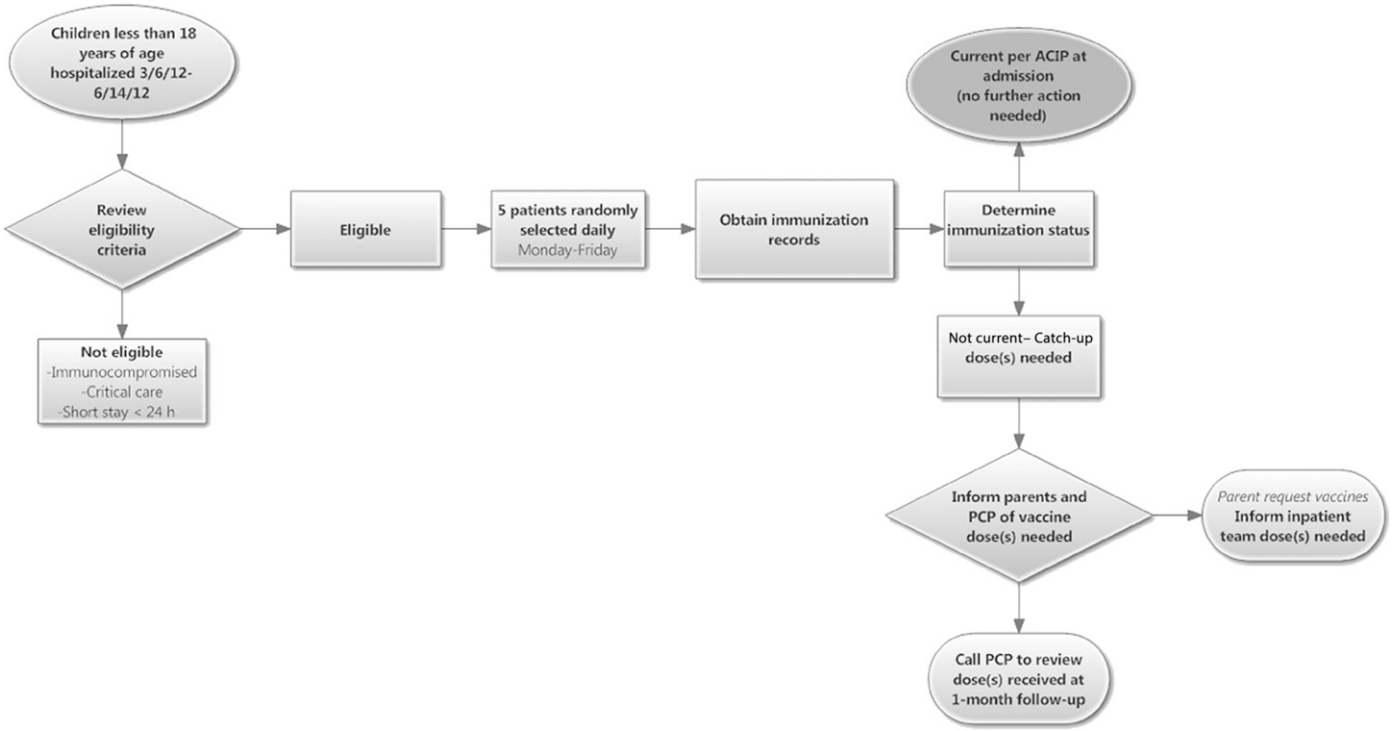

FIGURE 1 Process map of inpatient immunization screening pilot program.

TABLE 1 Demographics, Gender, Race, and Insurance Status of Children in Study ($n = 356$)

Age, y	
Median	5
Interquartile range	(1.3–9.7)
Gender	
Male	186 (52%)
Female	170 (48%)
Race	
White	221 (62%)
African American	61 (17%)
Hispanic	27 (8%)
Multiracial	20 (6%)
Other/missing	27 (7%)
Insurance	
Public	179 (50%)
Private	143 (40%)
Military	9 (3%)
Self-pay/other	25 (7%)

poliovirus vaccine; diphtheria, tetanus, and acellular pertussis vaccine for children up to age 7; *Haemophilus influenzae* type B vaccine; pneumococcal conjugate vaccine; hepatitis B vaccine; measles, mumps, and rubella vaccine; rotavirus; and diphtheria, tetanus, and acellular pertussis vaccine for aged ≥11 (Fig 3). The majority of these underimmunized children (77%) needed ≤2 vaccines to be considered current. Figure 3 shows which vaccines were required for catch-up among the underimmunized group and of those which were administered by the 1-month follow-up. HPV vaccine was the most needed catch-up vaccine, with 89% of HPV-vaccine eligible children requiring dose 1. The second most needed catch-up vaccine was VZV, and all children who needed it were aged >7 years; 70% of those needing a VZV dose required dose 2. All 95 underimmunized patients identified a PCP.

DISCUSSION

Our goal was to describe the immunization status of an inpatient pediatric population and to determine if a pilot intervention consisting of (1) obtaining immunization records of patients admitted to the hospital, (2) ascertaining their immunization status before discharge, (3) informing parents/legal guardians of dose(s) needed, and (4) following up at 1 month posthospital discharge with PCP would improve immunization status. Twenty-five percent of underimmunized children were caught up, with 66% of them receiving catch-up doses before discharge and 33% of them receiving catch-up dose(s) in the outpatient setting. Our intervention was successful at improving the immunization status of hospitalized children as "current" (has all recommended immunizations) per ACIP guidelines from 73% at admission to 80% at 1-month follow-up ($P < .001$). Our findings also mirror national data reporting suboptimal immunization coverage particularly for older school-age children and adolescents, specifically related to HPV vaccine, meningococcal conjugate vaccine, hepatitis A, and varicella vaccines.

Despite ongoing efforts from providers and established guidelines, only 7 in 10 US children have received appropriate childhood vaccines in the first 3 years of life.[13] Teenagers are also struggling to meet Healthy People 2020 targets, with 74% reported to have 1 dose of the meningococcal conjugate vaccine and only 28% of 13- to 15-year-old girls reported to have completed the HPV series.[14] Studies have shown that children in states with a higher number of medical homes receive childhood vaccinations at a higher rate than others.[15] However, nearly half of teenagers (the population least likely to be current per ACIP guidelines) lack a medical home,[16] making interventions for opportunistic immunization highly valuable in this population. When we informed parents/legal guardians of vaccine dose(s) needed, most of them seemed to be unaware of the catch-up dose(s) needed and willing to have their child receive them at their next health care encounter. It is interesting to note that all underimmunized

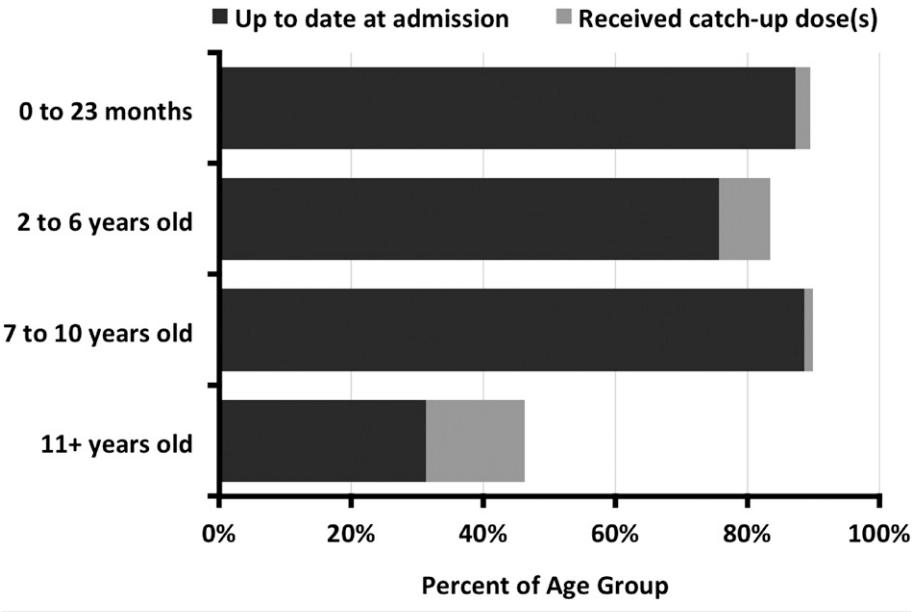

FIGURE 2 Immunization status of children per ACIP guidelines by age group ($n = 356$) pre- and postintervention.

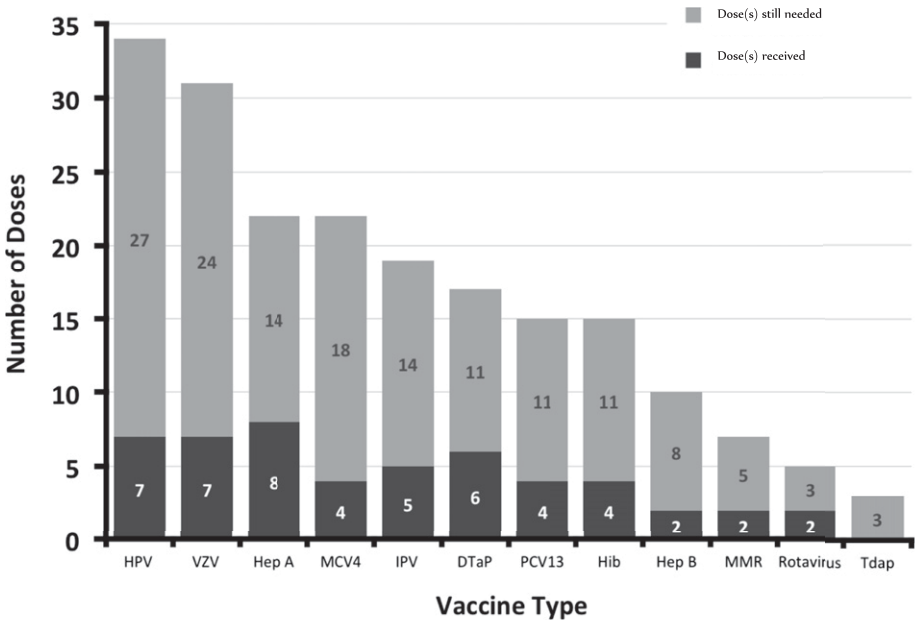

FIGURE 3 Number of catch-up doses needed ($n = 200$) at admission and at 1-month follow-up by vaccine type among 95 children found to be underimmunized per ACIP guidelines. DTaP, diphtheria, tetanus, and acellular pertussis vaccine for children up to age 7; Hep A, hepatitis A vaccine; Hep B, hepatitis B vaccine; Hib, *Haemophilus influenzae* type B vaccine; IPV, inactivated poliovirus vaccine; MCV4, meningococcal conjugate vaccine; MMR, measles, mumps, and rubella vaccine; PCV13; pneumococcal conjugate vaccine; Tdap, diphtheria, tetanus, and acellular pertussis vaccine for ages 11 and above.

patients could identify a PCP in our study, implying this resource is likely not being fully used. Most of the children who were caught up as a result of this pilot intervention were vaccinated before discharge per the request of the parents, suggesting that opportunistic immunization may be well received by parents.

Gilbert and Wrigley evaluated vaccination status in patients aged 3 to 23 months in the inpatient setting and showed that 85% of hospitalized children had vaccinations documented in the medical record, even though immunization records were rarely available.[7] After obtaining the immunization records, only 60% of the hospitalized children were current on their immunizations, and 79% of those who were behind on vaccinations had no follow-up action in place. Another inpatient immunization program increased immunization rates in 0- to 2-year-old children from 44% to 77% upon discharge by creating an immunization team that retrieved immunization records for each patient from the PCP and administered catch-up vaccinations to those needing catch-up dose(s).[8] The program was successful but labor intensive. Personal communication with the author revealed that the program was discontinued because (1) immunization rates in the city increased, resulting in fewer eligible inpatients over time; (2) a universal electronic health record in the primary care offices in their catchment area was created that allowed access at all times of immunization records, eliminating the need for the majority of phone calls to the practices; and (3) the city's centralized immunization database improved greatly over time, eliminating the need to call practices outside the hospital's health care network. Other studies have reported that immunization in their inpatient setting is not systematic but if improved could have a significant impact.[7,17–19] Development of a national immunization registry would eliminate the cost and time spent seeking immunization records across practices and states and would allow providers both in the inpatient and outpatient setting access to necessary information needed to determine the immunization status of every child seen in any health care setting. For our study, we required 0.5 FTE of a level 1 research coordinator to perform all activities related to this intervention.

Vaccine-preventable disease rates are rising in the United States and abroad; there have been 554 cases of measles reported in 20 states and 4558 cases of pertussis in California alone in 2014.[20,21] The Standards for Pediatric Immunization Practices, approved and endorsed by the US Public Health Service and the American Academy of Pediatrics, states that each health care encounter should be used as an opportunity to screen the immunization status of a child, and if immunizations are indicated, vaccines should be made available or the patient should be referred back to the PCP.[22,23] For these and many other reasons, including concerning national suboptimal immunization levels and gaps in sustainable immunization efforts, every health care encounter, including encounters in the inpatient setting, serve as an opportunity to immunize vaccine eligible children. Interventions for opportunistic immunization outside of the medical home or primary care setting may represent an important and innovative avenue to increase vaccination coverage. The inpatient setting may be especially well suited

to identify gaps in vaccine coverage, administer vaccines, and, most important, educate the underimmunized population. Barriers in the outpatient setting such as long wait times, difficulty with transportation and access, and perception that providers rush through encounters are generally absent in an inpatient setting, where the family is a captive audience during their hospital stay.

Our study is limited in that we followed immunization receipt only 1-month after discharge. We limited our follow-up time to 1-month in an attempt to be able to attribute the increase in immunization rates to our intervention rather than chance alone. It is possible that some children would have been caught up in the hospital or in hospital follow-up despite our intervention, so the effect size of our intervention may be somewhat overstated. However, the majority of children that were "caught up" received their immunizations in the inpatient setting, where catch-up immunizations (other than influenza, which was not included in this study) are not routinely administered. Our results may not be generalizable to other inpatient settings because we enrolled patients from a single hospital and collected information on a subset of randomly selected admissions. Only 843 of 3994 children were eligible for inclusion in large part because of our exclusion of short-stay admissions (<24 hours). Given our limited resources (0.5 FTE working days Monday–Friday), we were not able to obtain immunization records, determine immunization status, and inform caregivers of dose(s) needed in such a short time frame.

This is the first intervention reported in the literature developed to increase immunization status of pediatric patients of all ages in the inpatient setting. The majority of children who were caught up as a result of our intervention received vaccines while still in the hospital at the parent or legal guardian's request. This supports the notion that for most childhood vaccines, undervaccination may be due to lack of knowledge regarding the child's immunization status, lack of access, and other commonly encountered system-level barriers that can be overcome by interventions for opportunistic immunization such as this one. Notifying families of the need for vaccine(s) proved beneficial for most common childhood vaccines, but personalized vaccine counseling may be needed, particularly for teen vaccines and related to HPV vaccine. This study required 0.5 FTE level 1 research coordinator effort or ~4 hours of work per weekday during the enrollment period. Since the completion of this study, we have begun to incorporate the work performed by our salaried coordinator into the daily inpatient activities at our hospital as part of a quality improvement intervention that also provides maintenance of certification credit to those who participate. Further interventions at our institution will focus on systems-level barriers, as well as additional education for parents/patients and health care providers.

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REFERENCES

1. Centers for Disease Control and Prevention. Three cases of congenital rubella syndrome in the postelimination era—Maryland, Alabama, and Illinois, 2012. *MMWR Morb Mortal Wkly Rep*. 2013;62(12):226–229.
2. Cherry JD. Epidemic pertussis in 2012—the resurgence of a vaccine-preventable disease. *N Engl J Med*. 2012;367(9):785–787.
3. Sugerman DE, Barskey AE, Delea MG, et al. Measles outbreak in a highly vaccinated population, San Diego, 2008: role of the intentionally undervaccinated. *Pediatrics*. 2010;125(4):747–755.
4. Zipprich J, Hacker JK, Murray EL, Xia D, Harriman K, Glaser C; Centers for Disease Control and Prevention. Notes from the field: measles—California, January 1–April 18, 2014. *MMWR Morb Mortal Wkly Rep*. 2014;63(16):362–363.
5. Mills E, Jadad AR, Ross C, Wilson K. Systematic review of qualitative studies exploring parental beliefs and attitudes toward childhood vaccination identifies common barriers to vaccination. *J Clin Epidemiol*. 2005;58(11):1081–1088.
6. Niederhauser VP, Markowitz M. Barriers to immunizations: Multiethnic parents of under- and unimmunized children speak. *J Am Acad Nurse Pract*. 2007;19(1):15–23.
7. Gilbert R, Wrigley K. Opportunistic immunisation of paediatric inpatients at Rotorua Hospital: audit and discussion. *N Z Med J*. 2009;122(1298):25–30.
8. Bell LM, Pritchard M, Anderko R, Levenson R. A program to immunize hospitalized preschool-aged children: evaluation and impact. *Pediatrics*. 1997;100(2 pt 1):192–196.
9. Dorell CG, Jain N, Yankey D. Validity of parent-reported vaccination status for adolescents aged 13–17 years: National Immunization Survey—Teen, 2008. *Public Health Rep*. 2011;126(suppl 2):60–69.
10. Weddle G, Jackson MA. Vaccine eligibility in hospitalized children: spotlight on a unique healthcare opportunity. *J Pediatr Health Care*. 2014;28(2):148–154.
11. Williams ER, Meza YE, Salazar S, Dominici P, Fasano CJ. Immunization histories given by adult caregivers accompanying children 3–36 months to the emergency department: are their histories valid for the *Haemophilus influenzae* B and pneumococcal vaccines? *Pediatr Emerg Care*. 2007;23(5):285–288.
12. Esposito S, Marchisio P, Droghetti R, et al. Influenza vaccination coverage among children with high-risk medical conditions. *Vaccine*. 2006;24(24):5251–5255.

13. Centers for Disease Control and Prevention (CDC). National, state, and local area vaccination coverage among children aged 19–35 months—United States, 2012. *MMWR Morb Mortal Wkly Rep*. 2013;62(36):733–740.
14. Centers for Disease Control and Prevention (CDC). National and state vaccination coverage among adolescents aged 13–17 years—United States, 2012. *MMWR Morb Mortal Wkly Rep*. 2013;62(34):685–693.
15. Seipel MM. The impact of medical home on selected children's health outcome. *Soc Work Health Care*. 2011;50(5):347–359.
16. Holman DM, Benard V, Roland KB, Watson M, Liddon N, Stokley S. Barriers to human papillomavirus vaccination among us adolescents: a systematic review of the literature. *JAMA Pediatr*. 2014;168(1):76–82.
17. Walton S, Elliman D, Bedford H. Missed opportunities to vaccinate children admitted to a paediatric tertiary hospital. *Arch Dis Child*. 2007;92(7):620–622.
18. Conway SP. Opportunistic immunisation in hospital. *Arch Dis Child*. 1999;81(5):422–425.
19. Riley DJ, Mughal MZ, Roland J. Immunisation state of young children admitted to hospital and effectiveness of a ward based opportunistic immunisation policy. *BMJ*. 1991;302(6767):31–33.
20. California Department of Public Health. Pertussis Summary Report, June 24, 2014. Available at: http://www.cdph.ca.gov/programs/immunize/Documents/Pertussis_Report_6-24-2014.pdf. Accessed July 9, 2014.
21. Centers for Disease Control and Prevention. Measles (Rubeola). Measles Cases and Outbreaks, January 1 to July 3, 2014. 2014. Available at: http://www.cdc.gov/measles. Accessed July 9, 2014.
22. Recommended by the National Vaccine Advisory Committee. Standards for pediatric immunization practices. *MMWR Recomm Rep*. 1993;42(RR-5):1–10.
23. National Vaccine Advisory Committee. Standards for child and adolescent immunization practices. *Pediatrics*. 2003;112(4):958–963.

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