REVIEW ARTICLE

Pediatric Inpatient Immunizations: A Literature Review

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ABSTRACT

CONTEXT: Timely vaccine uptake in children remains suboptimal. Eliminating missed opportunities is key to increasing childhood immunization rates, and hospitalization offers another potential setting to vaccinate.

OBJECTIVE: To better understand pediatric inpatient immunization programs, including vaccination rates of inpatients, parental and provider attitudes, barriers to vaccine delivery, and interventions to increase provision of inpatient vaccines.

DATA SOURCES: A search was conducted of PubMed, Embase, and Web of Science to identify articles and conference abstracts related to pediatric inpatient immunization.

STUDY SELECTION: Inclusion criteria were studies published in English between January 1990 and January 2019 in which pediatric vaccination in the hospital setting was discussed. Findings from 30 articles and conference abstracts were summarized and organized by topic area.

DATA EXTRACTION: Abstracts were screened for relevance, articles were read, and themes were identified.

RESULTS: Children who are hospitalized have been shown to have lower immunization rates compared with the general population, with 27% to 84% of pediatric inpatients due or overdue for vaccines nationally when verified with official records. Unfortunately, little is done to catch up these children once they have been identified. Access to accurate vaccine histories remains a major barrier in inpatient immunization programs because providers frequently under document and parents over recall a child's vaccine status. Strategies identified to increase inpatient vaccination included creation of a multidisciplinary immunization team, educational interventions, visual reminders, catch-up vaccine plans, order sets, and nursing-driven screening. When offered inpatient vaccination, a majority of parents accepted immunizations for their children.

CONCLUSIONS: Hospitalization may provide an opportunity to augment vaccine uptake. Further research is needed to develop evidence-based strategies to overcome barriers to inpatient vaccination.

www.hospitalpediatrics.org
DOI:https://doi.org/10.1542/hpeds.2019-0026

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HOSPITAL PEDIATRICS (ISSN Numbers: Print, 2154-1663; Online, 2154-1671).

FINANCIAL DISCLOSURE: Dr Pannaraj receives research funding from Pfizer and MedImmune; and Dr Mihalek and Ms Kysh have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: Dr Pannaraj receives research funding from Pfizer and MedImmune; and Dr Mihalek and Ms Kysh have indicated they have no potential conflicts of interest to disclose.

Dr Mihalek conceptualized and designed the study and drafted the initial manuscript; Ms Kysh designed the search terms and critically reviewed the manuscript; Dr Pannaraj conceptualized the study and critically reviewed the manuscript; and all authors approved the final manuscript as submitted.

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Vaccines are 1 of the greatest public health achievements to date.[1–3] However, vaccination coverage remains suboptimal. In 2017, only 70% of children had completed the combined childhood vaccination series*, less than half of adolescents were up to date on human papillomavirus vaccination, and >40% of children had not received the seasonal influenza vaccine.[4–6] The American Academy of Pediatrics recommends using every health care visit as an opportunity to review and update vaccine status, and in their best practice guidelines, the Advisory Committee on Immunization Practices specifically includes a recommendation to immunize patients who are hospitalized.[7–9]

Hospitalization represents a potential setting to augment vaccine uptake: pediatric inpatients have lower rates of vaccination coverage than the general public, and hospitalization has been shown to be a risk factor for underimmunization in children.[10–16] Although the exact reason for this discrepancy is unknown, several causes have been hypothesized. Patient populations at some inpatient centers may have a lower socioeconomic status than those in the surrounding area, and children with chronic illness, who are more frequently hospitalized, may be perceived as too ill or may miss the usual time frame for outpatient vaccines.[13,17–20] Inpatient vaccination may also help to reduce health care disparities because discrepancies in inpatient immunization status have been demonstrated between income and racial and/or ethnic groups.[15,17,21] Patients who experience barriers to outpatient immunization, such as limited access to a primary care physician (PCP), transiency, and transportation difficulties, may have these barriers eliminated while hospitalized.[20,22,23]

Reducing missed opportunities by immunizing children who are hospitalized has been proposed for decades, yet little is known about this subject.[20] In an effort to further understand pediatric inpatient immunization delivery, from inpatient vaccination coverage to strategies to improve inpatient vaccine uptake, we reviewed the published literature for relevant articles.

METHODS

A search of PubMed, Embase, and Web of Science was conducted in November 2018 by using search terms developed in conjunction with our institution's clinical and research librarian. A combination of keywords and controlled vocabulary (when available) were used for the following concepts: vaccination, hospitalization, pediatric, and opportunistic or quality improvement (see the Supplemental Information for complete search strategies). Two hundred seventy-eight abstracts were identified and screened. Articles and conference abstracts available in English, published in 1990 or later, and pertaining to pediatric inpatient immunization were reviewed. Articles pertaining solely to the NICU and adult patients were excluded. Reference lists from each of the included articles were screened, and further applicable studies were identified. This process generated 30 articles and conference abstracts. Themes were identified, and results were organized into 4 topic areas: vaccination status of children who were hospitalized, accuracy of inpatient vaccine histories, barriers to optimal inpatient immunization programs, and interventions to increase documentation and delivery of vaccines to children who were hospitalized. This search was last repeated on January 9, 2019, to determine if new literature had been published during the production of this review.

RESULTS

Vaccination Status of Children Who Were Hospitalized

Multiple steps are required to successfully deliver immunizations in the inpatient setting, the first of which relies on determining a patient's vaccination status (Fig 1). Vaccination coverage rates among children who are hospitalized have been studied both nationally and abroad (Table 1, Fig 2). These studies occurred exclusively at single centers and with varied criteria for ages, for vaccines included, for what qualify as "overdue," and for whether verification with an official registry occurs. Thus, although exact comparisons between results may be difficult, studies consistently revealed that opportunities to immunize in the inpatient setting abound.

In the United States, vaccination status of pediatric inpatients of all ages was evaluated in 2 studies; in 1 study, the influenza vaccine was excluded from analysis, and in 1 study, it was included for analysis.[23,24] The former revealed that 27% of patients who were hospitalized required at least 1 vaccine, compared with 84% in the latter; in both studies, the majority of patients who were undervaccinated were adolescents.[23,24] In 3 additional studies, the preschool age group was evaluated exclusively, and it was shown that 38% to 56% of inpatients were due or overdue for at least 1 vaccine.[10,25,26]

Inpatient vaccination coverage has also been evaluated internationally, particularly in Australia and New Zealand, where national vaccine registries exist and assessment of immunization status and opportunistic immunization are hospital benchmarks of performance.[11,15,27–30] Fourteen percent to 34% of inpatients were due or overdue for vaccines in 5 studies from Australia.[11,12,14,17,31] In New Zealand, 40% of preschool-aged inpatients were due or overdue for immunizations in 1 study, and 52% were at least 4 weeks overdue in the second.[15,27] Six additional single-center studies in Europe and Africa revealed that 14% to 49% of inpatients were underimmunized.[13,21,22,32–34]

Factors associated with lower levels of vaccination coverage included ethnic minority groups,[15,17] lower socioeconomic status,[21] self-pay patients,[25] male sex, lack of day care attendance, history of previous missed opportunities to immunize, lack of transportation,[10] and increasing age.[24] Uptake of the influenza vaccine was also significantly associated with being fully up to date on other vaccines.[24] Authors of 2 studies collected data on outpatient

*The combined vaccine series, as defined by the National Immunization Survey-Child, is ≥4 doses of diphtheria, tetanus, and acellular pertussis; ≥3 doses of poliovirus; ≥1 dose of measles; ≥3 or 4 doses of *Haemophilus influenzae* type b; ≥3 doses of hepatitis B; ≥1 dose of varicella; and ≥4 doses of pneumococcal conjugate vaccines.[5]

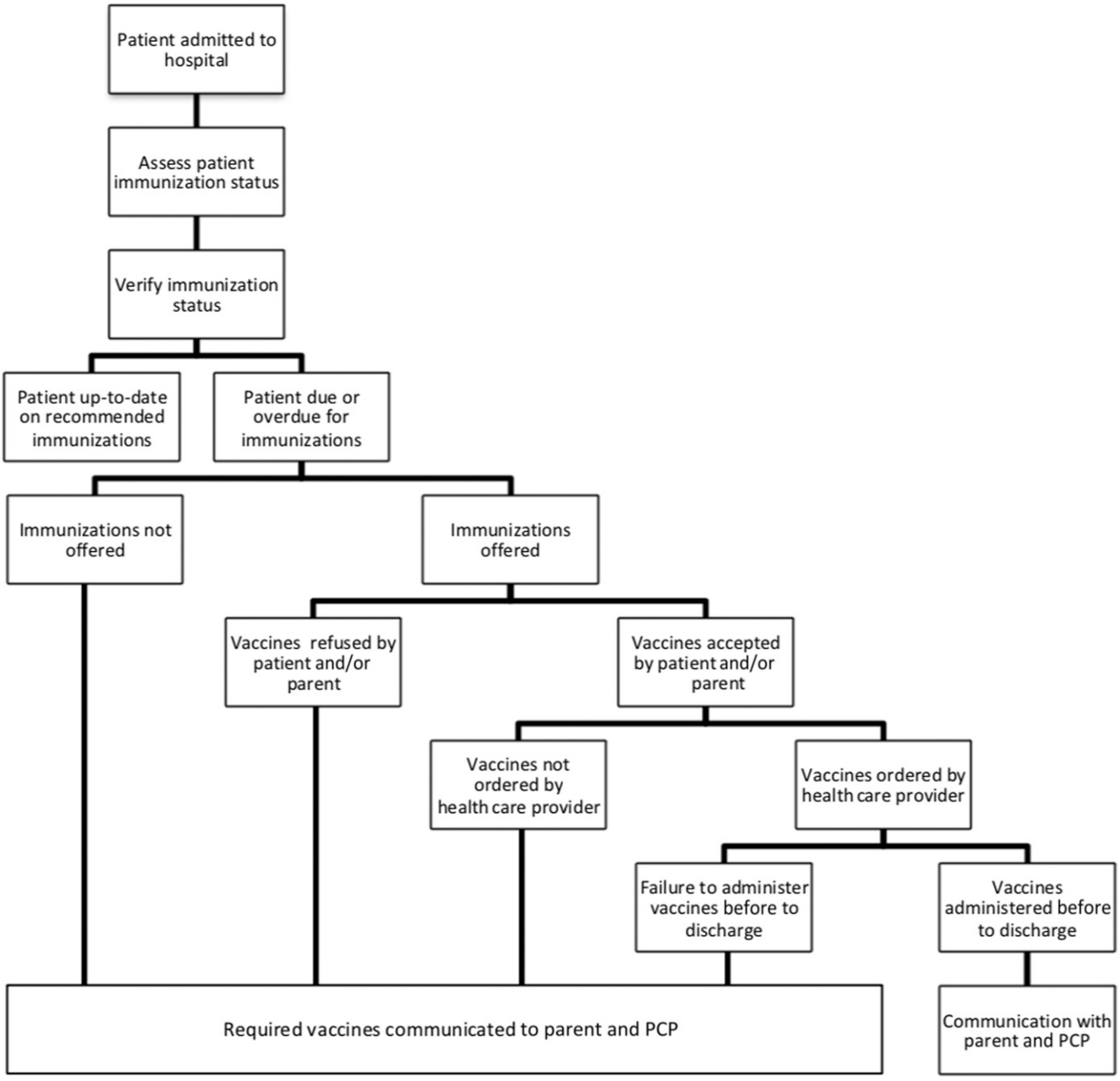

FIGURE 1 Key steps involved in delivering immunizations in the inpatient setting.

vaccination rates, finding generally lower immunization rates in inpatients.[14,15]

Research has also been focused on single vaccines, most notably the influenza vaccine, which has been shown to be cost-effective when delivered in the inpatient setting.[35] One study revealed that 42% of patients who were undervaccinated and hospitalized with influenza had experienced a missed vaccine opportunity, with 15% of these occurring during inpatient stays.[18] In addition, a study in which the Pediatric Health Information System database was used revealed that 16% of patients hospitalized with influenza had been hospitalized previously that season, suggesting a potential impact of an inpatient influenza vaccination program.[36] In these studies, patients with a previous visit and those with missed vaccination opportunities both increased in children with comorbidities.[18,36]

Accuracy of Vaccine Histories

Although children who are hospitalized may often be due for vaccines, the ability to immunize requires an accurate vaccine history. This can prove to be challenging in the inpatient setting. Providers have varying rates of documentation of inpatient immunization status, ranging between 63%

TABLE 1 Studies Used to Evaluate Vaccination Coverage in Children Who Were Hospitalized

Study	Location, Year	Population and/or Patient Age	Patients Due or Overdue for Vaccines, % (*n*)	Method of Verifying Vaccination Status
United States				
Pahud et al[23]	Kansas City, Missouri, 2012	<18 y	27 (356)	Official records (parent, PCP, state registry, school, birth hospital)
Weddle and Jackson[24]	Kansas City, Missouri, 2011	2 mo–17 y	84 (160)	Parent and/or PCP records
Bell et al[25]	Philadelphia, Pennsylvania, 1994–1995	0–2 y	51 (2006)	PCP records
Milteer and Jonna[26]	Washington, District of Columbia, 1991–1994	4–26 mo	35.4 (602)	Parent and/or PCP records; telephone calls to PCPs and/or clinics
Kum-Nji[10]	Memphis, Tennessee, 1992–1993	3–60 mo	56 (215)	Parent and/or PCP records; telephone calls to PCPs
International				
Elia et al[12]	Victoria, Australia, 2013–2014	6 wk–7 y	25 (3374)	National registry
Jose et al[17]	Western Australia, Australia, 2013	2 mo–6 y	18.6 (199)	National registry
Shingler et al[15]	Waikato, New Zealand, 2008–2011	<2.5 y	52.1 (324)[a]	National registry
Gilbert and Wrigley[27]	Rotorua, New Zealand, 2007	3–23 mo	40 (369)	Only verified if records were previously printed and placed in patient's chart (n = 43)
Ressler et al[11]	New South Wales, Australia, 2005–2006	2 mo–2 y	14 (573)	National registry
Muehleisen et al[33]	Basel, Switzerland, 2003	61 d–17 y	49 (430)	Official records
Walton et al[32]	London, United Kingdom, 2004	≥3 mo	20.5 (146)	Not verified
Anah et al[21]	Calabar, Nigeria, 2003–2004	≤5 y	39.1 (919)	Parent records
Conway[22]	Leeds, United Kingdom[b]	Preschool-aged patients[b]	18.3 (1000)	Parent records; telephone calls to local registry (health authority database)
Skull et al[31]	Northern Territory, Australia, 1996	<7 y	26 (102)[a]	National registry
Riley et al[13]	Manchester, United Kingdom, 1989–1990	5 mo–6 y	18.9 (296)[c]	Telephone calls to local registry (health authority immunization office)
Ferson[14]	New South Wales, Australia, 1989	3–25 mo	34 (204)	Parent records; telephone calls to PCPs
Conference abstracts				
Allen et al[34]	Truro, United Kingdom[d]	Unspecified	14 (400)[d]	Registry (child health database)

Study publication year as well as year of data collection, as included in each article's methods section, is included to aid in comparison with local vaccination rates and immunization schedule recommendations during that time period. Method of verifying vaccination status refers to the source of official records (i.e., "parent" indicates parent-held records, such as an immunization card, not parental recall and report).

[a] Vaccination rates from this study's preimplementation phase.

[b] The methods section does not define the exact dates of the study nor the specific age range for preschool-aged patients; however, in the results section, the authors discuss patients aged 3–66 mo.

[c] Greater than or equal to 3 mo overdue for vaccines.

[d] Data collection years and exact age criteria were not included in the conference abstract.

and 99% of admissions.[10,11,17,24,27,31,32] However, provision of a full immunization history, including documentation of all vaccines instead of merely writing "up to date," reveals more dismal results: 1 study revealed that this was completed in only 1.5% of patients.[32] In addition, discrepancies between parental or guardian (hereafter referred to as "parent") report and true vaccination coverage rates exist, with parental recall often overestimating vaccination status (Table 1).[10,17,22,24,27] This is compounded by the fact that parents often do not have formal immunization records with them at the time of hospital admission.[14] In 1 study, 92% of patients with inpatient vaccine histories were documented as up to date; however, only 23% were fully immunized when compared with PCP records.[24]

The inpatient setting provides additional time to obtain and verify a complete immunization history.[22] Interventions to improve vaccine history documentation were included in 2 studies: in 1, the implementing of staff education and a visual admission form; in the second, routine printing of vaccine records from an official database.[31,34] Both revealed significantly improved proportions of patients with adequate and accurate immunization histories after their interventions.[31,34] This suggests there are feasible strategies to

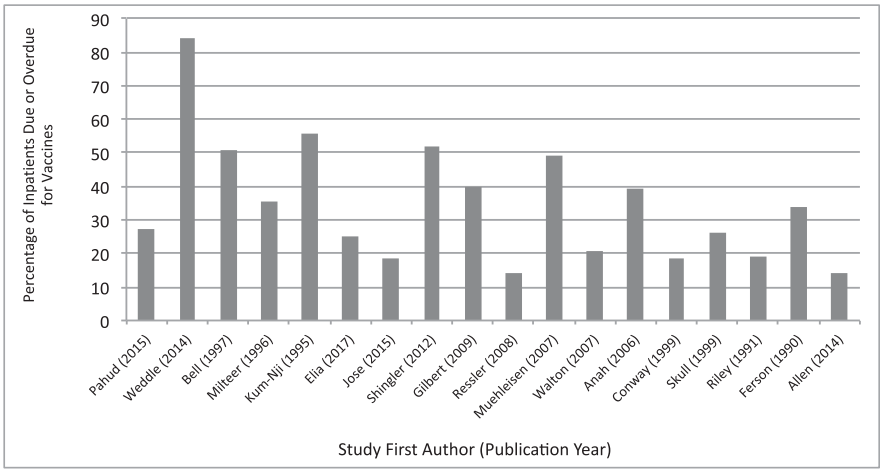

FIGURE 2 Percentage of inpatients requiring vaccinations.

optimize the ability of providers to deliver vaccines to children who are hospitalized.

Inpatient Interventions

Unfortunately, 1 common theme in the published literature is that when children who are hospitalized are recognized as underimmunized, little is done to catch them up.[17,27,32] Authors of various studies have tested interventions to improve vaccine delivery; these interventions were largely performed at single centers and had varying degrees of complexity, ranging from simply offering vaccines to the construction of full immunization delivery teams (Table 2).

Four studies were focused on verifying vaccine status with official records and offering inpatient catch-up vaccines; ultimately, 23% to 75% of eligible patients were vaccinated.[13,21,22,25] In 1 of these studies, the authors trialed multiple means of communicating the need for vaccines with inpatient providers and found that visual reminders were most effective.[25] Staff education and visual prompts led to a 14% increase in opportunistic inpatient vaccination in an additional study, whereas routine printing of official immunization records in another improved identification, but not catch-up vaccination, of patients who were underimmunized.[31,34]

The authors of 2 studies developed individualized catch-up vaccine plans for patients who were underimmunized.[11,23] In 1 study, 25% of eligible patients were brought up to date within 1 month of discharge; the second study revealed that patients who were given a plan were significantly more likely to have received needed vaccines 30 and 90 days later.[11,23] In a third study, inpatient vaccine counseling to parents and PCPs led to a significant increase in patients receiving catch-up vaccines within 1 month of discharge.[33]

In 2 studies, authors relied on an immunization champion as the focus of their intervention.[12,15] In 1, 42% of patients overdue or due for immunizations received catch-up vaccines within 1 month of discharge, 51% of whom were vaccinated while hospitalized.[12] The other intervention occurred in the inpatient setting, the emergency department, and outpatient hospital-based clinics simultaneously, and 68% of eligible patients were vaccinated across these settings.[15] Missed opportunities were identified in 17% of eligible patients, with a majority of these occurring in inpatients.[15]

Strategies to increase influenza vaccination rates were also evaluated (Table 3). In 1 study, the authors compared provider reminders, family education, and electronic medical record (EMR) prompts, and showed that provider reminders were the most effective method.[37] In another, the authors evaluated a nurse-driven screening and vaccine-ordering tool and found that patients in the intervention period had significantly increased rates of influenza screening and vaccination.[38] A third study was focused solely on patients with cancer, and an influenza vaccine was included in the hospital admission order set as part of a multifaceted inpatient and outpatient intervention.[39] Although the overall percentage of patients receiving and completing the influenza vaccination series increased, the proportion vaccinated in the inpatient setting was unchanged.[39]

In addition to the influenza vaccine, 2 studies were focused on pneumococcal polysaccharide vaccination in special populations.[40,41] In 1 study, nursing-driven assessments and standing orders were used to increase vaccination in children who were hospitalized with risk factors as well as in adults who were hospitalized at their institution; in the second study, staff education and EMR order sets were used for patients with diabetes mellitus, and both led to increased inpatient immunization rates by 15% and 43%, respectively.[40,41]

Through these studies, lessons were learned that may better inform further interventions. Increased involvement and empowerment of the nursing staff was frequently cited in successful programs, and multiple studies relied on a nurse coordinator or on nursing-driven protocols to improve vaccine uptake.[12,13,15,38,40] Further strategies for improvement included the development of clinical guidelines, standardized screening forms, online staff resources, EMR prompts, education, and adding underimmunization to a hospitalized patient's acute problem list.[12,18,22,42,43] These mirror approaches already identified in the adult literature, including nursing-driven vaccination screening, standing orders, immunization histories taken by pharmacists, clinical pathways, chart reminders, and patient education.[40,44]

Barriers

Challenges surrounding construction and implementation of optimal inpatient immunization programs were identified. One frequently cited barrier, as noted previously, is lack of an accurate vaccine history or lack of easily accessible immunization records.[17,25] The steps needed to verify immunization status can be time consuming if they are not streamlined into the admission process.[13,22,23,25] Additional

TABLE 2 Studies Used to Evaluate Inpatient Interventions to Increase Vaccine Uptake in Reverse Chronological Order

Study	Study Design	Intervention	Results
Elia et al[12]	Quality improvement, pilot program ($n = 3374$)	Immunization services team constructed, missing vaccines offered, or plan developed before discharge	42% of patients due or overdue brought UTD within 1 mo of discharge (51% vaccinated in inpatient setting)[a]
Pahud et al[23]	Quality improvement, pilot program ($n = 356$)	Catch-up plan created; missing vaccines administered to inpatient or communicated with PCP	25% of patients due or overdue brought UTD within 1 mo of discharge (66% vaccinated in inpatient setting)
Shingler et al[15]	Quality improvement, pilot program ($n = 1304$)[b]	Clinical nurse immunization coordinator established; missing vaccines offered (inpatient setting, emergency department, outpatient hospital clinics)	67.5% of patients without contraindication vaccinated across all settings[a,c]
Ressler et al[11]	Retrospective cohort study ($n = 41$)[b]	Catch-up plan given before discharge	Patients given plans more likely to receive catch-up vaccines within 30 d ($P < .005$) and 90 d ($P < .04$) of discharge
Muehleisen et al[33]	Nonrandomized controlled trial ($n = 430$)	Parents and PCPs notified of missing vaccines before discharge	27% of patients given inpatient counseling versus 8% in the control group received ≥1 catch-up vaccine within 1 mo of discharge ($P < .001$); 45% (inpatient counseling) versus 35% (control) received ≥1 catch-up vaccine within 9 mo of discharge ($P > .2$)
Eckrode et al[40]	Quality improvement, pilot program ($n = 624$)	Standing pneumococcal vaccine orders, nurse-based assessments (patients ≥65 y old and patients 2–64 y old with risk factors)	Patients offered pneumococcal vaccines increased from 8.6% to 59.1% ($P = .00$); pneumococcal vaccination rates increased from 0% to 15.4% ($P = .00$)
Anah et al[21]	Descriptive study ($n = 919$)	Immunization status verified; missing vaccines offered[d]	34.5% of eligible patients immunized before discharge; patients fully UTD increased from 60.9% to 74.4%[a]
Conway[22]	Quality improvement, pilot program (n = 1000)	Immunization status verified; missing vaccines offered	23% of patients due or overdue were offered immunization in inpatient setting; 65% accepted immunization before discharge[a]
Skull et al[31]	Quality improvement, pilot program ($n = 230$)[e]	Staff education, increased vaccine availability, visual prompts, and vaccine history form implemented	Eligible patients immunized increased from 0% to 14% ($P = .054$) and from 0% to 62% in patients identified as underimmunized ($P = .005$)
Bell et al[25]	Quality improvement, pilot program ($n = 2006$)	Immunization status verified; missing vaccines offered	66% of patients due or overdue were immunized in inpatient setting; patients fully UTD increased from 44% to 70% by discharge ($P < .0001$)
Riley et al[13]	Quality improvement, pilot program ($n = 296$)	Immunization status verified; missing vaccines offered	75% of eligible patients vaccinated in inpatient setting[a]
Conference abstracts			
Seagroves et al[41]	Quality improvement, pilot program ($n = 199$)	Staff education, inclusion of PPSV23 in DM EMR order sets	PPSV23 immunization rates in inpatients with DM increased from 0% to 43%[a]
Allen et al[34]	Quality improvement, pilot program ($n = 400$)	Immunization records printed from official database; staff awareness raised	No change in catch-up immunization rates (0% pre-discharge)

Studies exclusively used to evaluate the influenza vaccine are described in Table 3. DM, diabetes mellitus; PPSV23, 23-valent pneumococcal polysaccharide vaccine; UTD, up to date.

[a] *P* values are not provided for these statistics.

[b] Sample size refers to patients eligible for immunization or the intervention.

[c] Includes opportunistic immunizations in the inpatient setting, the emergency department, and outpatient hospital (not PCP) clinics; authors did not stratify analysis by site of immunization.

[d] Exact methods for offering inpatient vaccines and the time line of postdischarge follow-up was not specified in the methods section.

[e] In the study, the authors evaluated both inpatient and emergency department settings (sample size and results for inpatient data only).

TABLE 3 Studies Used to Evaluate Inpatient Influenza Immunization Exclusively

Study	Study Design	Influenza Season(s)	Methodology	Major Findings
Interventions				
Rao et al[37]	Quality improvement, pilot program ($n = 1657$)	2014–2015	Compared vaccination rates between control (EMR prompts), family education, and provider-reminder groups	Vaccines ordered between groups ($P < .0001$): provider reminder: 52%; family education: 30%; control: 25%
Freedman et al[39]	Quality improvement, pilot program ($n = 1128$)	2012–2013	Multiple outpatient intervention, 1 inpatient intervention (vaccine in admission order set); pediatric patients with cancer	Patients receiving ≥1 vaccine increased from 54.8% to 77.7%; 10% of vaccines received in inpatient setting (no change from previous rate)
Pollack et al[38]	Retrospective cohort study ($n = 42\,716$)	2003–2012	Compared screening and vaccination rates before and after implementation of a nurse-driven EMR tool	Screening increased from 19.8% to 81.1% ($P < .001$); vaccination increased from 2.1% to 8% ($P < .001$)
Surveys and missed opportunities				
Rao et al[42]	Descriptive study ($n = 1001$ parents and 195 providers)	2014–2015	Surveyed inpatient parents and providers regarding attitudes toward inpatient influenza immunization	92% of parents who usually vaccinate child against influenza and 37% of parents who do not usually vaccinate child against influenza would agree to inpatient immunization; 91% of providers believe inpatient influenza vaccination is important
Rao et al[18]	Retrospective cohort study ($n = 322$)	2010–2014	Determined proportion of patients hospitalized with influenza with a missed vaccination opportunity at same hospital	61% of patients hospitalized with influenza were undervaccinated; 41.7% had a missed opportunity (15% of missed opportunities from inpatient visits)
Cameron et al[43]	Retrospective cohort study ($n = 786$) (2 sites)	2013–2014	Determined percentage of patients who received vaccine in inpatient setting and factors associated with refusal	49.8% of eligible inpatients refused vaccination; factors associated with vaccine refusal included: female sex ($P = .05$), white race ($P \leq .01$), private insurance ($P = .01$), and not otherwise up to date on vaccines ($P = .02$)
Zerr et al[36]	Descriptive study ($n = 184\,332$) (PHIS database)	2002–2006	Identified patients hospitalized for influenza or respiratory illness; determined percentage hospitalized earlier during same influenza season	16% (influenza) and 12% (respiratory illness or influenza) admitted earlier that season; patients with comorbidities: 23% (influenza) and 17% (respiratory illness or influenza) admitted earlier that season

All descriptions of vaccines or vaccination refer to the influenza vaccine. Studies pertaining to interventions to increase inpatient influenza vaccine screening and delivery are presented first. Studies occurred at single centers unless otherwise noted. PHIS, Pediatric Health Information System.

obstacles to opportunistic immunization programs included absence of formal policies and systems regarding inpatient immunization, insufficient staff knowledge and training, lack of physician confidence in discussing vaccinations with parents, out-of-date parental information, limited vaccine supply, staff perception that there is not adequate time to address immunizations, and reluctance to vaccinate children who were hospitalized.[17,19,21,27,32] In a study of the influenza vaccine, providers identified forgetting to assess immunization status or order the vaccine as barriers to inpatient immunization.[42]

Provider attitudes regarding inpatient vaccination, and the perception that immunization is exclusively the realm of the PCP, can also represent a challenge to opportunistic immunization programs.[19] In 1 study, staff members involved in direct patient care were interviewed, and it was found that 55% expressed concerns about the appropriateness of immunizing children in the inpatient setting or at a tertiary center; the authors of 2 further studies cited the need for provider buy-in for successful inpatient vaccination programs.[21,22,31] In contrast, inpatient providers had a favorable opinion of inpatient vaccination in a study in which the influenza vaccine was evaluated, and a majority of outpatient pediatricians and family physicians agree with vaccination in the inpatient setting, especially those practicing in high-risk urban areas.[32,42,45] Finally, although inpatient providers may assume patients will have unobstructed access to PCPs and outpatient immunization, this does not always hold true (all of the patients who were underimmunized in 1 study identified a PCP).[23]

Inpatient providers may also express concerns that parents will not accept immunization while their child is hospitalized; however, this was not the main finding in these studies. In 1 pilot program designed to increase inpatient vaccine uptake, only 6% of parents of eligible children refused vaccination.[25] Additional studies echoed this, revealing that most parents were willing to have their children immunized while hospitalized and were sometimes unaware that their child needed catch-up vaccine doses.[13,21–23,26] This was also seen with the influenza vaccine; a majority of parents in 1 study reported that they would agree to inpatient influenza immunization, including 37% who did not regularly vaccinate against influenza.[42] When reasons for parental refusal of inpatient influenza vaccines were evaluated in a separate study, vaccine refusal was found to be more likely in patients who were white, girls, privately insured, and otherwise not up to date on immunizations.[43]

DISCUSSION

Although children who are hospitalized may have lower vaccination rates than those in the general population, currently, little is done to identify or catch up pediatric inpatients who are underimmunized. In the United States, between 27% and 56% of pediatric inpatients were due or overdue for vaccines during hospital admission, and this number increased to 84% when the influenza vaccine was also included.[10,23,24] Although outpatient practices will remain the primary setting for delivering immunizations, this large proportion of underimmunized hospitalized children reveals that the inpatient setting may provide a greater opportunity to increase vaccine uptake than is often acknowledged. Hospitalization gives time to verify vaccine records, provide vaccinations, and educate families on the importance of vaccines before discharge.[20] The inpatient setting also represents a largely untapped niche for vulnerable groups of patients, such as adolescents who may visit their PCP less frequently or children with chronic medical conditions who may be at higher risk of complications from vaccine-preventable infections.[18,38,46–48]

Although providers may be interested in delivering catch-up vaccines to children who are hospitalized, the inability to obtain an accurate and accessible vaccine history remains a major barrier. Strategies for streamlining access to electronic state-based or national immunization registries, as well as standardized screening methods, deserve investigation. In addition, the hospital-level cost and societal benefits of stocking and delivering vaccines to inpatients, especially in the era of diagnosis-related reimbursement plans, has yet to be fully explored. Hospital partnerships with the Vaccines for Children program, which provides vaccines free of charge to eligible patients, may be 1 strategy to mitigate hospital costs; however, meeting the program requirements of ordering and maintaining separate Vaccines for Children and private stocks in a large institution may lead to further obstacles.

Parental and provider attitudes regarding inpatient immunization have begun to be investigated, but further research in this realm is warranted. To date, there are no published studies on attitudes regarding inpatient administration of a majority of vaccines, including adolescent immunizations. Collaboration with PCPs must also be a cornerstone to any successful opportunistic immunization program, and interviews with outpatient providers could identify best practices for information sharing after vaccines have been delivered. Successful communication with PCPs and state-based vaccine registries are needed to prevent duplicate vaccine doses and to maintain the correct intervals between vaccine administrations.

There are currently no published studies in which pediatric inpatient immunization practices across the country are described because the literature to date largely consists of single-center studies with a variety of methodologies. Research into the rates at which inpatient vaccines are given at various hospitals and research into contributing factors could inform best practices and strategies to increase inpatient vaccine delivery and develop effective workflows. In addition, single-center pilot studies could be expanded into multicenter prospective efforts to ensure that the most robust and replicable methodology is used. Finally, interventions that have been successfully used for 1 immunization type, such as nurse-driven influenza screening and vaccine ordering, could be implemented in additional vaccine groups.

CONCLUSIONS

The large number of pediatric inpatients who are underimmunized reveals a potentially significant public health impact if assessment of vaccine histories and vaccine delivery in the hospital setting can be optimized. Parents are largely accepting of opportunistic inpatient immunization, and strategies have begun to be explored to increase inpatient vaccine uptake. Further research is needed to investigate inpatient immunization practices more broadly, thereby identifying key strategies for increasing childhood vaccine uptake overall.

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