The Purpose and Functions of Immunization Information Systems Within Health Care Organizations

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A broad coalition of public and private health care organizations advocate the development of computerized immunization information systems as a key national strategy for achieving and sustaining high immunization coverage levels. However, widespread adoption requires greater awareness of the purpose, functions, and value of an immunization information system within health care organizations. We propose that the purpose of an immunization information system is to increase the efficiency and effectiveness of immunization-related practices and identify 9 potential functions that accomplish this purpose through improving patient care and practice management. When implementing an immunization information system within a practice setting, health care providers must consider technological and organizational issues. Health care providers should also look beyond their particular practice setting and establish public-private partnerships to create a system that links immunization data from all health care providers.

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Editor's Note: This article provides an excellent argument that a computerized immunization information system is a key strategy for achieving and sustaining higher immunization levels nationally. All that is needed for implementation is evidence that it will save or make money, the health of children notwithstanding.

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The immunization status of 2-year-old children has become a key quality-of-care indicator for health care organizations.[1] Approximately one fourth of US children 19 to 35 months of age are underimmunized,[2] and coverage rates vary widely among health care providers. Evidence suggests that the immunization practices of health care providers contribute substantially to the variation in immunization rates.[3] The development of computerized immunization information systems is a major national strategy to help health care providers address the problem of underimmunization. Among other functions, these systems allow health care providers to access and exchange electronic immunization records at various sites and to generate reminder notices to inform parents when children are due for immunizations. The proved effectiveness of timely reminder messages to parents[4-7] has provided impetus for the development of immunization information systems. While state and local health departments have a mandate to develop such immunization systems,[8] interest is not limited to the public sector. There are many examples of private-sector initiatives to develop immunization information systems that support the provision of quality health care.[9-11]

Much of the national dialogue about immunization information systems has focused on the public health sector and the need for communitywide development.[9] Although the community perspective is critical, system designers also must consider the perspective of the health care provider to ensure that health care providers and health care organizations benefit from the immunization information system. Therefore, we address the purpose, potential functions, and implementation of an immunization information system for health care organizations, including the importance of public-private collaboration.

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THE PURPOSE OF AN IMMUNIZATION INFORMATION SYSTEM

Although experts have recommended key features of an immunization information system,[9,12] they have not stated its basic purpose. The diverse terminology used to describe immunization information systems (eg, "computer-generated reminder systems,"[4,5] "immunization registries,"[9,13] "immunization tracking systems,"[10] and "computerized immunization information systems"[14]) also suggests a lack of consensus regarding the fundamental purpose of such systems. This issue is not merely academic; a clearly stated purpose provides the foundation for system design and guides the consideration of design options.[15]

The common theme in the diverse terminology describing immunization information systems is the management of information to improve immunization practices. We, therefore, propose the following simple concept: the purpose of an immunization information system is to use information technology to increase the efficiency and effectiveness of immunization-related practices. Given this concept, health care providers can carefully consider particular functions that an immunization information system might perform. Not only does this concept suggest functions commonly associated with immunization information systems (eg, reminders for parents and record access for physicians), but it also challenges health care providers to think of other ways in which information technology might be used to improve immunization practices.

When referring to an immunization information system, we mean a set of functions rather than a specific configuration of hardware and software. In some settings, immunization information systems are nested in more comprehensive systems that apply information technology to a broad range of health services. Rather than address the breadth of such systems,[16] we present a picture of how information technology can be applied to immunization services in particular, offering a prototype of how an information system might support various health services.

SYSTEM FUNCTIONS IN A HEALTH CARE ORGANIZATION

To provide preventive health care effectively, providers must focus on the provision of preventive services during patient care (ie, the critical path)[17] and on the management of the wider office system supporting the patient care process.[18,19] An immunization information system can, thus, improve immunization practices through functions that facilitate either patient care or practice management. Patient care functions assist the health care provider in providing clinical care (eg, providing access to immunization histories during a patient encounter). Practice management functions assist the health care provider in managing the wider office system (eg, providing data for continuous quality improvement).

Patient Care Functions

To immunize a child during a clinical encounter, a health care provider typically proceeds through a series of steps that can be made more efficient and effective when supported by an immunization information system. **Figure 1** shows the supporting functions of an immunization information system in relation to the clinical process.

Reminders to Health Care Providers. Studies suggest that many clinical encounters with children younger than 2 years are missed opportunities to immunize and that immunization coverage of 2-year-old children could be increased 12% to 22% if these patient encounters were used as opportunities to immunize.[3,20] During clinical encounters, potential immunization administration begins with the health care provider remembering to review the child's immunization status. Despite standards for assessing immunization status at every patient encounter,[21] health care providers often fail in this step.

An immunization information system can help reduce missed opportunities for immunization by instituting automatic reminders to the health care provider at each patient encounter. Reminders generated from a computer system using algorithms based on current practice guidelines can automatically determine and display patient eligibility for specific immunizations.[22] Twenty years of research support the effectiveness of reminders in improving physician behavior.[22-28] Physician reminders have been shown to increase the provision of preventive services up to 5-fold,[25] work effectively in fee-for-service and health maintenance organization settings,[27] add substantially to the influence of parental reminders alone,[26] and maintain their effectiveness over time.[27] Reminders cue health care providers to their own attitudes that endorse preventive care, leading these attitudes to influence their behavior.[28]

Immunization Record Access. Once the health care provider remembers to review a child's immunization status, access to a reliable immunization history is necessary. The American Academy of Pediatrics,[21] Elk Grove Village, Ill, and the National Vaccine Advisory Committee,[29] Washington, DC, recommend the development of immunization information systems to assist health care providers in reliably determining and documenting patient immunization status. Currently, health care providers often lack access to accurate immunization records during a given patient encounter. Many children see multiple health care providers between birth and 2 years of age, and parents often fail to transmit to each health care provider an accurate, complete record for their child's immunization history.[30] One study found that the lack of a reliable immunization history resulted in missed opportunities for more than 30% of new patients.[31] Record access is, therefore, an important function of an immunization information system because it allows health care providers to administer all of the appropriate immunizations while avoiding repeats of vaccinations.

Informational Support for Clinical Decisions. Based on available immunization data, a health care provider must decide whether a child is due to receive specific immunizations, whether use of an aggressive catch-up schedule is warranted, and whether valid contraindications or precautions are present. Even assuming that physicians have
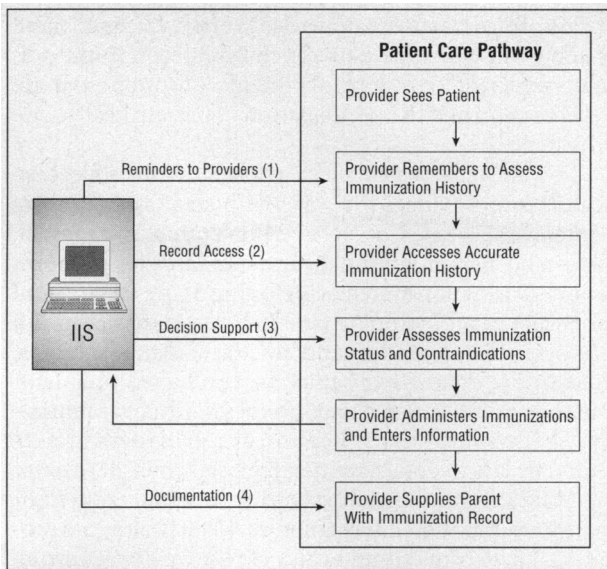
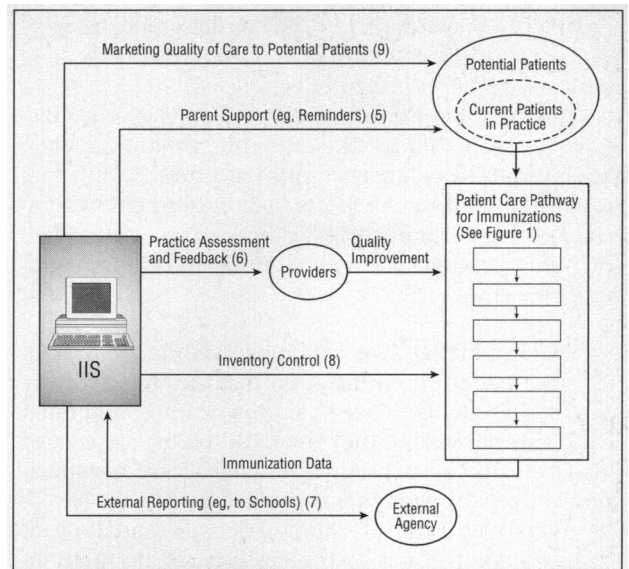**Figure 1.** *Patient care functions of an immunization information system (IIS).*

Figure 2. *Practice management functions of an immunization information system (IIS).*

superior information processing abilities, unavoidable limitations can result in missed opportunities for immunization. Health care providers may miss opportunities by relying on simple decision-making heuristics,[32] such as following the standard immunization schedule when an aggressive catch-up schedule is appropriate; by not following the most current immunization schedule, which changes frequently; or by not accurately assessing a child's status.[33] Further, surveys of family physicians and pediatricians have documented that many are overly conservative in their interpretation of symptoms as contraindications.[34] A decision-support module can guide health care providers through a decision tree to determine whether a child is due for immunizations, whether presenting symptoms constitute a contraindication or precaution, and whether use of a catch-up schedule is warranted.[35] Decision-support systems have been effective in aiding clinical decision making in other medical settings[15] and can eliminate a principal cause of missed opportunities for immunization. Pressure to apply these tools to preventive care is increasing, given the focus of managed care on achieving compliance with evidence-based standards of care.[36]

Documentation. After administering the vaccine and recording the appropriate information, the health care provider must generate documentation such as updated immunization histories for paper-based medical records and the parent's copy of the immunization history. Studies suggest children are more likely to be up-to-date if parents possess their child's immunization record[37] and know when the child's next immunizations are due.[38] An immunization information system can automatically print out documentation such as the parent copy of the child's immunization history, including indication of when the next immunizations are due.

Practice Management Functions

In addition to intervening directly in patient care, immunization information system functions can help health care providers manage their practices more efficiently and effectively, as shown in **Figure 2**. Data can be aggregated to evaluate the overall immunization process and to support parents and health care providers.

Support for Parents. In contrast with the support offered to individual parents during a clinical encounter, the parent support function supports groups of parents through reminder messages and outreach efforts. For example, health care providers can use an information system to generate routine reminders and recall messages for patients who are due or past due for immunizations. Such messages can increase immunization visits by 8% to 34%, depending on the patient population and message protocol.[4-7] Parents appreciate such notices,[4] which can be delivered effectively via postcards[6] or telephone calls.[4,5] Delivery of messages via autodialing is particularly cost-effective.[5]

Immunization information systems can also target more effective outreach efforts. In one study, targeted outreach to a cohort of high-risk children produced an 18% increase in immunization rates.[39] Some health care providers have integrated geographic information systems with their immunization system to identify geographic pockets of need and use this information to deploy mobile vans or other community outreach efforts.[40]

Practice Assessment and Feedback. The Standards for Pediatric Immunization Practices[21] recommend reviews of patient medical records and feedback to the health care provider about practice immunization rates. In addition, health care providers in health maintenance organizations must allow assessment of immunization rates to meet Health Plan Employer Data Information Set requirements for quality assurance certification.[1] Lacking objective data, health care providers typically overestimate the provision of preventive services in their practices,[41,42] including immunization rates.[3] Assessment and feedback are effective strategies for changing the behaviors of health care providers in general[43] and immuniza-

tion practices in particular.[44,45] Nevertheless, the labor required to conduct manual assessments has raised questions concerning cost-effectiveness.

Immunization information systems perform practice assessments more efficiently by providing a database for automated analysis and reporting. Health care providers can use such reports to monitor their own immunization rates and correct practices associated with low immunization rates (eg, simultaneous administration of vaccines).

External Reporting. Not only must health care providers report patient immunization histories to child care centers, preschools, schools, summer camps, and other health care providers, they may also report aggregated data to health departments, managed care organizations, and quality assurance organizations (eg, the Health Plan Employer Data Information Set[1]). Trends toward greater organizational accountability and population-based management and more research likely will increase such demands in the future.[44] An immunization information system can increase practice efficiency by performing these reporting activities automatically.

Inventory Control. Many health care providers find monitoring vaccine inventory a cumbersome task. Health care providers accepting public sector vaccine as part of the Vaccines for Children program must account for the vaccines received and doses administered. An immunization information system can facilitate inventory control by monitoring the current stock, estimating demand, and electronically placing vaccine orders.

Marketing. Health care organizations benefit from marketing their services, especially in a competitive managed care environment. Reminders generated by an information system increase patient retention by prompting parents to return and by demonstrating the health care provider's concern for the child's health. Because immunization rates are used to measure quality of care, organizations can attract new patients by documenting and marketing a high immunization rate. The marketing function of the immunization information system can improve immunization practices indirectly by rewarding health care providers who document high immunization rates, thereby providing incentive to improve immunization-related practices.

Interorganizational Collaboration

Given the mobility of the US population, health care providers routinely must share immunization information to determine their patients' immunization status to maintain continuity of care. Therefore, the immunization information system of a health care organization can achieve its full potential only when linked to an external, population-based system. A statewide information system linked to a computerized birth registry enables health officials to track all children regardless of whether they make regular visits to the same health care provider.[9] With the support of federal funding, states are developing statewide immunization information systems, although the extent of progress to date varies widely. Because these systems must include data on children seen in the private sector, success depends greatly on public-private collaboration and the participation of private health care providers.

Several technical and legal considerations affect how health care providers interface with state systems. The Centers for Disease Control and Prevention, Atlanta, Ga, has established minimum design standards for immunization information systems, including a core data set and the Health Level 7 (Ann Arbor, Mich) standards for health care systems integration and electronic data exchange. In addition, data sharing must be conducted in a manner that maintains patient privacy and confidentiality.[13,46] In some states, health care providers are required by law to obtain written parental consent to enter the child's immunization record into a state system or share immunization information between health care providers. Laws concerning health care provider reporting also vary from state to state, with reporting mandatory in some cases. Health care providers can obtain information specific to their area by contacting their state or local health departments.

Organizational Issues

Regardless of the degree of public-private collaboration achieved, health care providers maintain ultimate responsibility for successfully implementing immunization information systems in their practice. For example, health care providers must integrate the system technology with the larger organization of people and procedures.[47] If users have difficulty with the computer interface, they may waste time, enter incorrect data, or bypass the system entirely. The user interface must be designed to enable rapid and flexible interactions, and users must be adequately trained.[48] Whenever possible, the immunization information system should be accessible at the point of service and fully integrated into the patient care pathway, allowing a wider range of functions to be used (eg, record access and clinical decision support).[49] Technology can improve workflow integration, such as using bar codes to automate data entry.[50] Furthermore, procedures must be established to maintain and verify database accuracy. Paper-based immunization records are known to be error prone,[30] and immunization information systems can be plagued by similar problems.[51]

The immunization information system should be implemented as part of a continuous quality improvement effort.[18,19,52-54] The Centers for Disease Control and Prevention version of continuous quality improvement, known as AFIX (assessment, feedback, incentives, and information exchange), has raised immunization rates by as much as 20% to 40% in public clinics in several states.[44,45] Similar strategies also have raised rates in private practices[44] and health maintenance organizations.[54] Whereas an immunization information system provides data on practice immunization rates and critical aspects of health care provision (eg, simultaneous administration of vaccine), continuous quality improvement methods guide use of the data to improve quality of care.[18,19,52] In addition, a focus on continuous quality

improvement helps health care providers view assessment positively rather than as a means for placing blame.

Technological Considerations

Implementing an immunization information system in a health care organization involves many technical decisions. Organizations must decide whether to acquire software from their health department, buy from a vendor, or create their own. In addition, organizations must decide whether to implement a stand-alone system or to create a system linked to a computerized patient record and/or billing, scheduling, and pharmacy system(s). Because the needs of health care organizations differ by organization type, number of practice sites, existing computer resources, and degree of coordination with the state system, no single information system design will meet the needs of all organizations. Regardless of these decisions, however, organizations should consider use of national Health Level 7 standards to facilitate the transfer of immunization information between different computer systems and avoid costly interfaces. Given these considerations, the following cases provide examples of immunization information systems implemented in diverse computer and organizational environments. Note that the types of functions supported by these systems vary, with more advanced systems supporting more functions.

Case 1. Two years after implementing their immunization information system, the Group Health Cooperative of Puget Sound, Wash, reported an increase in their health maintenance organization's immunization rates from 79% to 91%.[55] The data repository for the system is housed on a mainframe computer. Workstations allow health care providers in a variety of clinical sites to access clinical data, practice guidelines, allergy information, immunization status, pharmacy profiles, and laboratory results. Such a system can prevent missed opportunities to immunize patients by generating reminders for health care providers, increasing access to immunization histories and other necessary patient information, providing information on contraindications, and printing updated immunization records for parents. Management of immunization administration is supported through sending parental reminders, inventory control, routine practice assessment, and use of the assessment data to market the organization's quality of care.

Case 2. The software provided by the Arizona State Immunization Information System, Phoenix, enables health care providers to capture immunization data directly from the health care provider's billing claim system, eliminating the need to rekey information.[56] This software captures *Current Procedural Terminology* codes and patient demographic data, creating a practice-specific immunization database. The system supports real time and batch transfer of immunization data to and from the state registry, providing timely updates and allowing health care providers to print immunization histories on demand. In addition, the system enables providers to send reminder or recall notices, control vaccine inventory, and conduct routine practice assessments.

Case 3. Practices lacking computer resources still can participate in an immunization information system by submitting data via mail, fax, or telephone to a central registry. In Oregon, health care providers place adhesive, bar-code labels on scannable forms and then mail these forms to the state system.[50] The Oregon registry then processes this data for health care providers and returns reports documenting patient immunization histories and practice immunization rates.

CONCLUSIONS AND RECOMMENDATIONS

Informatics research provides strong evidence for the effectiveness of several information-based interventions to improve clinical outcomes.[15] A well-designed immunization information system can incorporate many such interventions, including reminders for parents and health care providers, access to accurate immunization histories, support for clinical decision making, and automated assessment of practice rates. To realize these gains, health care providers should help design, implement, and integrate immunization information systems into their practices. Although development of an immunization information system may seem a tall order to some, the process is well underway in many organizations and is increasingly feasible given the development of public-private partnerships.[56]

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