Technology Strategies for a State Immunization Information System

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The New Jersey Comprehensive Immunization Program (NJ-CIP) is a collaborative project of The Robert Wood Johnson Medical School and the New Jersey Department of Health and Senior Services. It is an All Kids Count (AKC) project, funded by The Robert Wood Johnson Foundation, to develop a pilot State Immunization Information System (SIIS) in Camden, New Jersey, and plan for the expansion of the system throughout New Jersey. NJ-CIP initially sought technical expertise from university settings to promote a research-based selection of the technical components of the software and network. A technical team was created to focus on future needs, using prototyping for the application and selecting the best emerging technology, instead of relying only on what was commercially available at the start of the project. The technical team has positioned the project to pursue a variety of deployment options, funding sources, and partnerships with major hospital/provider organizations to move from a pilot to the NJ SIIS, and to qualify New Jersey as an Information Network for Public Health Officials (INPHO) state, through the following key technical directions: (1) establishing open systems technical architecture, including use of the Internet as the wide-area network connecting sites; (2) developing a standards-based application software using the National Vaccine Advisory Council minimum data set, and providing interfaces to the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)/Aid to Families with Dependent Children (AFDC), the Electronic Birth Record, and Clinical Assessment Statistical Application (CASA), including a Health Level 7 (HL7) interface for data exchange; (3) piloting a variety of reproducible deployment models from the Camden sites, all supporting both on-line use and electronic interfaces to local data systems. Medical Subject Headings (MeSH): immunization; information systems; computer systems development; computer communication networks; computer software; medical record linkage. [Am J Prev Med 1997;13(Suppl 1):51–7]

The New Jersey Comprehensive Immunization Program (NJ-CIP) is developing for the state of New Jersey an electronic registry that eventually will contain data on all immunizations given to children residing in the state. There is a wide variety of project participants, that is, state programs offering immunization services (such as the Special Supplemental Nutrition Program for Women, Infants, and Children [WIC] and Aid to Families with Dependent Children [AFDC]), Federally Qualified Health Clinics, hospital newborn nurseries, pediatric departments and clinics, private or group practices affiliated with hospitals, private physicians, and health maintenance organizations (HMOs). About 80% of childhood immunizations are administered by private providers. NJ-CIP initially proposed a prototype registry in April 1994; it is now undertaking a full application and data base development project to create the registry data base and the applications necessary to enable its use.

From the start, New Jersey recognized that the success of all these projects would depend on the strength of the wide-area network that supported them. Similarly, it was recognized that a consistent and well-articulated technical architecture was the cornerstone of a successful set of projects (Figure 1). The Internet was selected as the appropriate wide-area network early in the project, and its use has been the catalyst for a variety of activities: providing network access to project participants, promoting expansion of the network to other health-related information projects, and providing technical leadership to information technology staff members at the NJ Department of Health and Senior Services (DoHSS), hospital systems, and other stakeholders.

Why the Internet? New Jersey's state government does not

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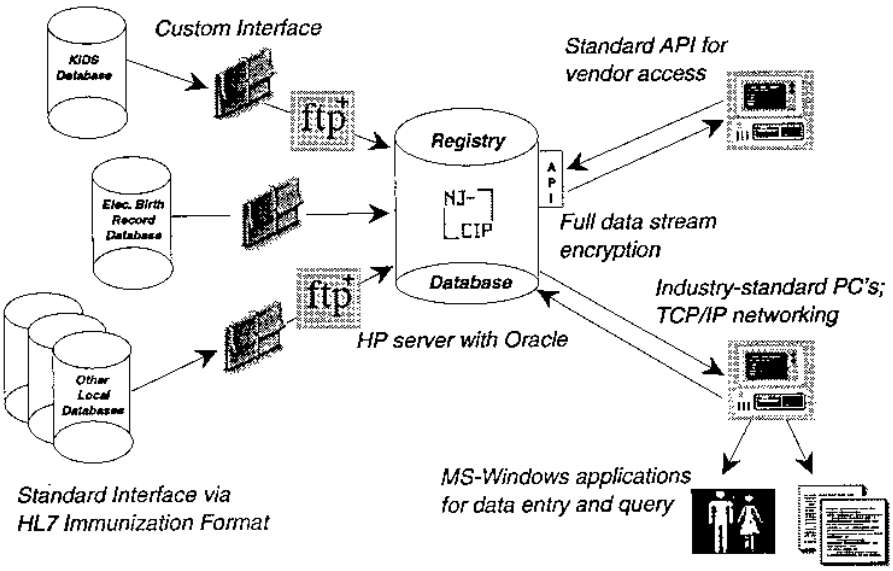

Figure 1. Technical architecture. The technical architecture defines the hardware, software, and communications components for the project. The Internet was a key component of the NJ-CIP architecture.

have a wide-area network deployed that is appropriate to the technologies that were needed for a modern, client/server system. In addition, since a major factor in deploying a registry in New Jersey is providing appeal to private practitioners in the absence of any mandating legislation, the Internet and its wealth of information resources is an attractive lure for participation in the program. Finally, Internet-related technology represents products that are fairly vendor-independent and standards-based.

Goals of the Registry

From a technical point of view, the goal of the State Immunization Information System (SIIS) is to provide two major functions: (1) the ability to query the registry for the purpose of determining or verifying the immunization status of a particular patient, and (2) the ability to use the registry to trigger appropriate reminder, recall, and outreach programs for those patients who are underimmunized.

The project created a *mature* registry during the pilot phase. "Mature" means a fully populated registry with the complete immunization history of as many preschool children in the pilot city (Camden) as possible, rather than just a prospective registry that would start with current immunizations or newborn children alone and build a data base forward. In this way, the project could assess *now* whether a fully populated registry would achieve its chief goal of increasing immunization rates in a target population before a permanent statewide effort was launched. It also exposed the project early to the difficulties of merging data from multiple sources so that data deduplication and validation edits could be incorporated into the design and into ongoing quality assurance processes.

Initial Technical Challenges

A number of challenging technical issues were present as the project began, and some persisted well into the pilot phase: (1) local information systems are already deployed in some of the organizations that participate in the pilot project; (2) the development is taking place during a period of rapid organizational change in health care delivery systems and their own information technology support direction; (3) the exact functionality to be provided by the registry and its applications were not fully determined at the start of the project because of changes in the health care environment and the roles of the HMOs vis-à-vis public health; (4) the nature of incentives, technical or otherwise, which may need to be provided to encourage use of the registry especially by private physicians was not initially known; and (5) an analysis needed to be done as to the appropriate means of integrating each site's data into the SIIS. Some sites have local systems that can support electronic records transfer, but many sites require traditional on-line data entry or data query applications.

System Prototype

The first phase of the implementation of this project (in April 1994) was a data base and application prototype, that is, an early, experimental version of a data base or computer application that is used to understand how the data base or application will behave when it is in production, or final, status. The objectives of the prototype were (1) to demonstrate the robustness of a data model that had been initially developed, (2) to provide sample applications to show to project participants, and (3) to develop specifications for the production products to be built or acquired by identifying the *right* features and functions.

A relational data base was created on a Unix server platform. A prototype application was developed and presented to project sponsors in the spring of 1994. The sponsors were able to look at a real application and envision how such a system might work. The demonstration also contained a live connection to the Internet, which at the time was not as widely known in the health care community as it is today. Based on this prototype, the sponsors decided to contract with the University of Pennsylvania to develop a full SIIS project, data base, and applications, and test it in Camden City.

Technical Architecture

The registry is being deployed as a client/server system. The technical architecture for the project is displayed in Figure 1. The major components of the architecture follow.

Data base. The data base management system is the Oracle 7 relational data base management system running on a Unix server.

Client computers. The client computers are industry-standard personal computers running MS-Windows 3.1 (at least initially). Typical configuration includes at least a 66 MHz Intel 80486 (or Pentium) processor, 500+ MB of disk space, 16 MB of RAM, and a 15-inch SVGA monitor.

Network protocol. Transmission Control Protocol/Internet Protocol (TCP/IP) is being used exclusively for this project.

Wide-area network. The Internet is the wide-area network connecting client sites with the data base server.

Applications. Client applications are written initially in the MicroSoft-Visual Basic language, relying on Oracle SQL*Net and OPBC as middleware connecting the client applications to the registry data base via TCP/IP.

Query tools. Additional "off-the-shelf" commercial SQL query tools are deployed relying on SQL*Net connectivity.

Data collection. Data will be brought into the registry via custom interface to the WIC/AFDC KIDS system, via custom interface to the Electronic Birth Record System, and via an HL7 interface written to the draft immunization record standard (Version 2.3, Ballot #1, February 25, 1996) to other local data systems found in clinical provider locations.

Data access. At a later time, if the Centers for Disease Control and Prevention (CDC) National Immunization Program Data Management Division has not addressed this issue for all of the projects, we will consider developing an applications program interface (API) to allow vendors to write software that accesses data in the registry for transfer to local data systems found in clinical provider locations. This API will likely be based on HL7.

User access. Data base users normally receive data base user names and passwords only (as opposed to operating system user names and passwords). SQL*Net encrypts the data base password as it travels across the network, with a session key, but does not support user alteration of the password.

Use of the Internet

In April 1994 using the Internet for wide-area communications, especially in health care, was considered a bold and risky strategy. New Jersey, however, with its dense urban and suburban populations and deepening penetration of Internet service providers, seemed a natural fit for this kind of strategy. Although a statewide network did (and does still) exist (the Garden State Network operated by the Office of Telecommunications and Information Services in the State Department of the Treasury), it did not embrace the open-systems, standards-based protocols necessary to support modern, client/server applications. NJ-CIP wanted to offer its participants the wealth of information that was available even then on the Internet as a benefit or incentive for participating in the registry. Finally, the tools that were emerging, most notably the World Wide Web (WWW), were viewed as strategic resources to enable delivery of information to project participants and curious colleagues from around the world.

How Is the Internet Used?

The Internet is used in a variety of ways to support the SIIS project, and these methods will all be expanded as the Information Network for Public Health Officials (INPHO) project is implemented.

Wide-area network for SIIS application. The SIIS application is a client/server system using an Oracle back-end data base and a front-end application being developed at the University of Pennsylvania for deployment initially under MS-Windows 3.1 (and eventually Windows 95 and NT). It is built upon TCP/IP as its communications protocol and is being deployed over the Internet as its wide-area network. The initial sites for the pilot project in Camden City are deployed over a private extension of the University of Pennsylvania's campus network; encryption technology is being tested that should allow subsequent sites to attach to the Internet via the service provider of their choice, and still be able to connect securely to the SIIS server.

World Wide Web in support of the SIIS application. WWW technology is being used directly in support of the SIIS application deployment (Figure 2). Users receive software updates and full on-line documentation and help information via the WWW. A wealth of additional information is brought to project participants through the WWW as well: immunization material from CDC and other government organizations, overall health information local to New Jersey and around the world, and information on relevant professional organizations and societies and the services and information they provide.

World Wide Web in support of project development. WWW technology is also used extensively in support of the management of the project. A password-protected area of the Web contains internal project team documents: a site deployment checklist, an application enhancement/modification list, open and closed application "bug" lists, and developing specification documents. Updates happen frequently, and the WWW browser becomes a singular piece of software for delivering this information to project staff and selected collaborators at user sites.

World Wide Web in support of information dissemination. As both an AKC and CDC project, NJ-CIP is committed to share information about its developments with similar projects around the country and around the world. Through the creative use of WWW technology, project working papers, documentation, samples, and newsletters can be made available easily and inexpensively to a wide audience. Products such as Adobe Acrobat allow documents containing text, graphics, and images to be created and disseminated in their original form with compact file sizes and no ability for the viewer to compromise the integrity of the original information (unlike distribution of an original word processing file). Reproduction and distribution costs are minimized as the burden shifts from mailing by the project to retrieval on the reader's part.

Electronic mail. From its very inception, NJ-CIP has been a collaborative project, bringing together three major universities in two states (New Jersey and Pennsylvania), multiple state agencies and divisions, a multitude of health care providers, and a broad base of community organizations. Electronic mail (e-mail) has been an absolute necessity in maintaining project communications at the frenetic pace necessary to deploy a major, developing system successfully. E-Mail was instituted among these participants not only to enable intraproject communications, but to enable (and encourage) communications external to the project as well.

Data transfer. A key feature of the technical architecture of the SIIS is the harvesting of immunization data from local data systems at provider sites. The Internet supports a robust file transfer protocol (ftp), with easy-to-use products, for the transmission of data files to and from the project.

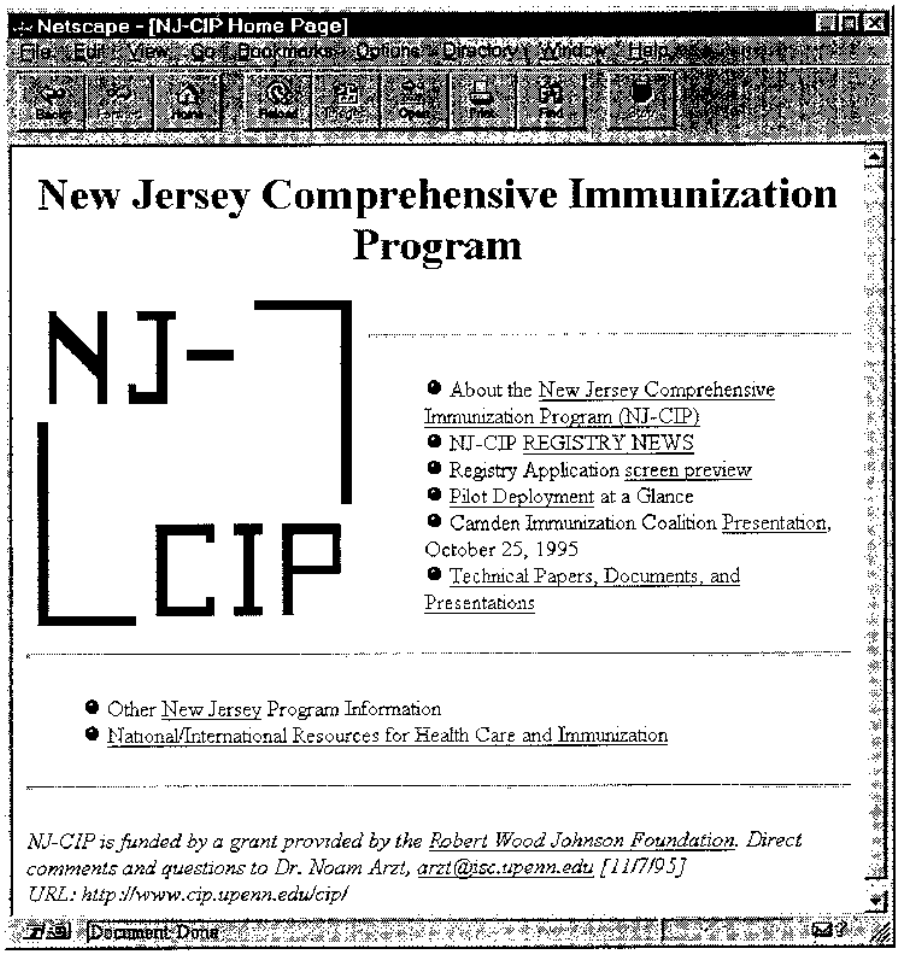

Figure 2. NJ-CIP home page. The World Wide Web is used extensively to support the development and deployment of the products developed by the project, and to help inform users and prospective users about issues important to childhood immunization.

Internet Access

A major focus of the project has been providing Internet access to project participants. The SIIS pilot project has extended the University of Pennsylvania campus network, with its connection to the Internet, to a local Internet service provider in southern New Jersey via Integrated Services Digital Network (ISDN) connections in a cost-effective manner (Figure 3). Public and private immunization provider sites are then attached to this network, which provides access to the SIIS server (located in pilot mode at the University of Pennsylvania; in full production it will be elsewhere) and full Internet access for electronic mail and WWW browsing. INPHO funding adds significantly to the number of sites that will be brought on board, deployment of similar infrastructure to support a laboratory surveillance project, and deployment of the same infrastructure to public health officers in local health departments around the state.

Security Concerns

Security is always a big concern in any information system deployment. Use of the Internet only brings a new dimension to this problem. A formal security assessment was done for all components of New Jersey's deployment, and specific steps are taken to harden information and data base servers from attack, to ensure desktop security, and to encrypt data wherever possible when it passes over the network. To stay on top of security concerns as the Internet evolves and the product marketplace emerges requires constant attention on the part of the technical team. Specifically, the following steps were taken as the SIIS became operational.

Policy. An information security policy that delineates the roles and responsibilities of the program staff and participants with respect to the registry and its data was developed, including appropriate procedures to ensure that local site data and software are properly managed.

Harden server against network attack. Several steps were taken to harden the server against attack from the Internet, including the installation of additional data security software and hardware, and restriction of unnecessary network functions.

Train staff appropriately. Appropriate systems and operations training was provided for staff, including backup personnel. Outside consulting assistance was provided when necessary.

Physically secure the server. The data base server is kept in a locked facility, with an alarm system armed whenever left unattended. Uninterrupted power is provided. Data backups (including off-site storage of backup media) are in place and functioning. Restoration from backups is periodically tested.

Prevent promiscuous access to data. Via Oracle's Secure Network Services, the full client/server data stream can be encrypted

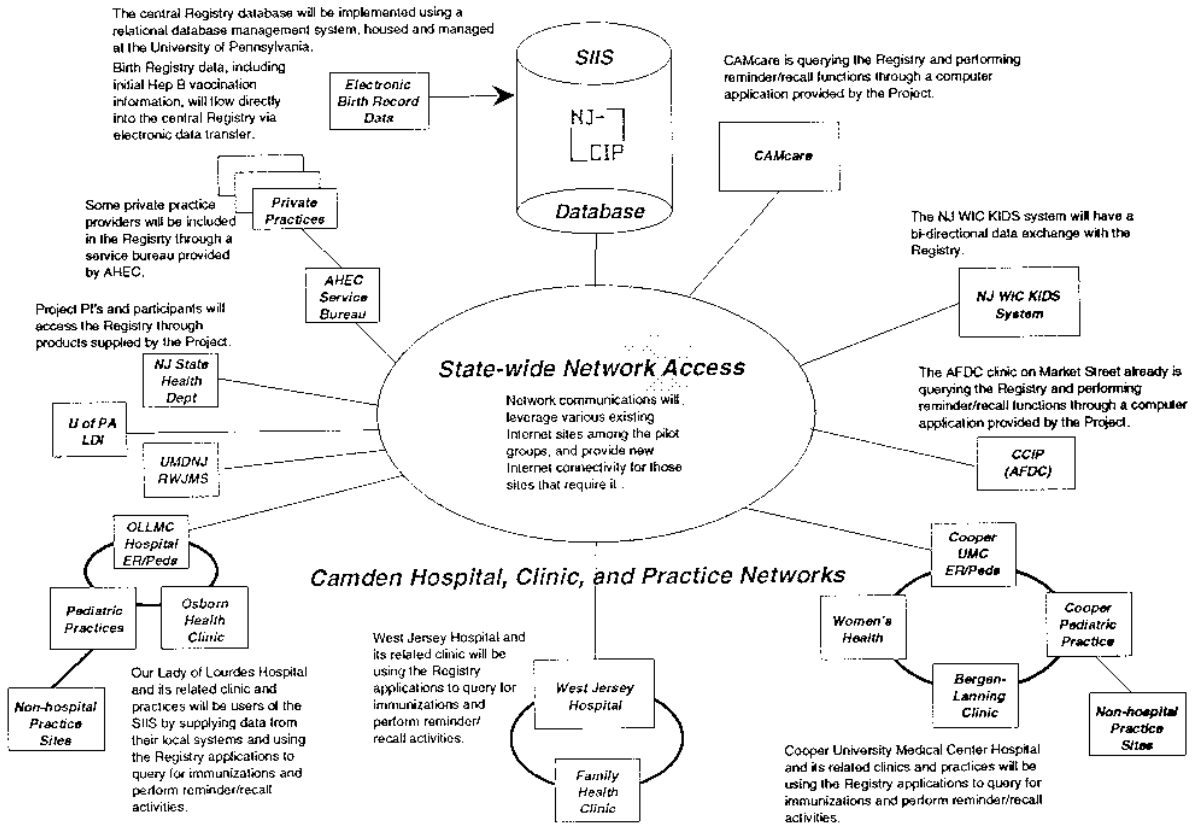

Figure 3. NJ SIIS pilot. The SIIS Pilot Project involves clinical sites from a wide variety of public and private health care providers in the target city. Abbreviations: SIIS, state immunization information system; CAMcare: name of federally qualified health center in Camden, NJ; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children; KIDS, name of immunization reminder/recall system implemented by New Jersey WIC; CCIP: Camden County Immunization Program; AFDC, Aid to Families with Dependent Children; Cooper UMC, Cooper University Medical Center, a hospital affiliated with the University of Medicine and Dentistry of New Jersey; OLLMC, Our Lady of Lourdes Medical Center; UMDNJ RWJMS, University of Medicine and Dentistry of New Jersey Robert Wood Johnson Medical School; U of PA LDI, University of Pennsylvania's Leonard Davis Institute of Health Economics; AHEC, Area Health Education Center, which operates a service bureau and coordinates deployment of the registry in the pilot city.

to prevent even accidental disclosure of data by promiscuous capture on the network.

Standards

One critical success factor for the project is the use of both models and standards. Technical standards can apply to industry-standard components, such as hardware and data bases, or to those approaches, methods, and data formats adopted by national groups such as HL7, American National Standards Institute (ANSI), American Society for Testing Materials (ASTM), etc., to promote system interoperability and data transfer. These standards organizations comprise members of industries (such as health care, computing, insurance, etc.) who agree to work cooperatively on standards development, vote on their acceptance, and publish them for use. Vendors then incorporate the standards in the manufacture and development of products to ensure a wide marketplace for them.

Models are prototypes or data designs that can be used as guides to development. Where standards and models clearly exist, the project has embraced them both as a way to move forward quickly and to ensure acceptability of the products in the health care and information systems environments where they would be used. Examples of CDC models and development are the core data set adopted by the National Vaccine Advisory Committee (NVAC), a planning paper on the data system model, and a planning paper to assist in developing the assessment algorithm. CASA (Clinical Assessment Software Application) is a major CDC product, and its interfaces are well documented.

Some standards selected for use by the project include an open architecture client/server approach, TCP/IP as a networking protocol, an SQL-compliant relational data base management system, and standard hardware specifications that cover a wide variety of vendors and sources and can be obtained easily by project participants.

HL7 is a major data message standard widely used by vendors of health information systems for hospitals and other clinical settings. CDC joined the HL7 Working Group and spearheaded the development of an HL7 standard for an immunization record

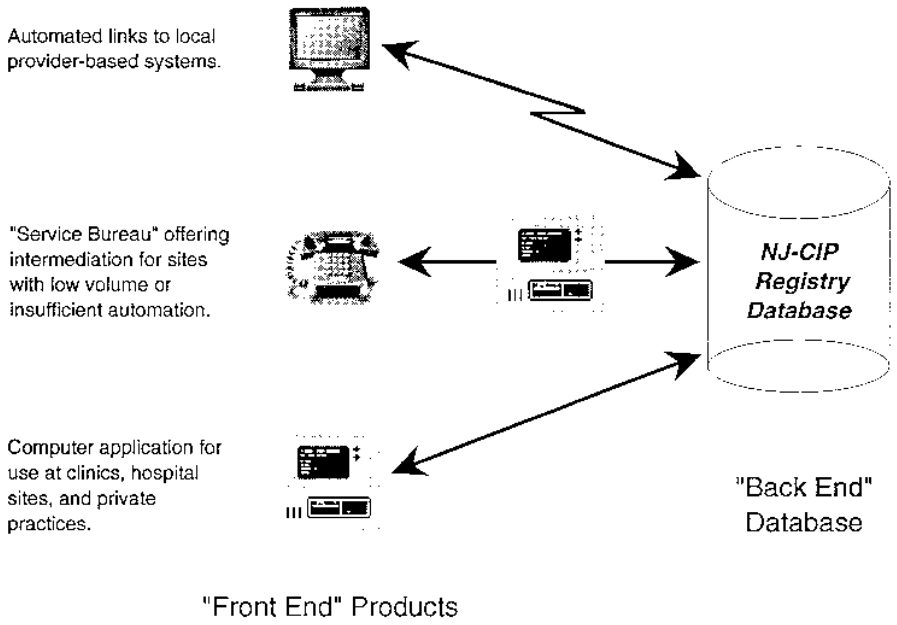

Figure 4. Deployment options. A number of deployment options were used in the pilot implementation.

that incorporates the core data set. Work on this standard began in April 1995, and it is still (May 1996) in draft. The project saw the use of the HL7 immunization record as strategic in dealing with emerging integrated health delivery systems such as managed care organizations and hospital–physician networks, especially those that are building data warehouses for clinical data and that want to link records of ambulatory care and inpatient and outpatient services.

The project took the initiative in developing an HL7 data extract standard and, in collaboration with CDC and other interested state projects, and designing an interface engine with HL7-compliant interfaces to manage the passing of messages between systems.

Deployment Options

A number of deployment options were used in the pilot implementation to test the usefulness of each one (Figure 4).

Automated interfaces to local systems. A variety of interface options were developed for local data systems for the purpose of harvesting immunization information without rekeying data. Integration of electronic data was a challenge because of great variations in data quality resident in local provider-based systems.

After the initial data base was electronically populated with WIC/AFDC data and other providers were added, we identified serious data quality problems. During the first quarter of 1996, we undertook a data clean up, deduplication, and verification process on the entire data base, before adding the three hospital clinics. Computer analysis identified the numbers of records with duplicates and data quality problems, giving priority to records of children under 2 years of age. The sites first "tagged" the records to claim responsibility for their patients, checked the registry records against their paper files, and indicated that they had verified the data using a "verified flag" so that each site could evaluate the condition of the records during the data cleanup and have a basis for ongoing quality assurance. To improve the editing of incoming records, a special "verified flag" as well as a two-tiered verification procedure and an enhanced soundex algorithm were added to the registry application. A quality assurance consultant tested data quality in each of the new sites before they were brought on-line, wrote procedures for adding future new sites, and provides continuous quality monitoring.

Service bureau. A service bureau was established at the local Area Heath Education Center (AHEC) in Camden to provide a method of starting to have private physicians use the SIIS for query and reminder/recall, even if this use was indirect. The service bureau interacts with these physicians primarily by fax and telephone, receiving and responding to queries about specific patients and supporting customized reminder, recall, and outreach activities for these doctors. This implementation is so popular that it has been expanded as a field office for the project in the local community, serving as a beta test site for product upgrades, acting as an agent of the New Jersey Department of Health and Senior Services managing consent forms and issues, and staffed with a data specialist to coordinate deduplication procedures and other quality assurance measures.

On-line access. Of course, direct on-line access to the SIIS was the main thrust of the project. Initially, five sites in Camden were brought on-line and supported using the registry applications developed by the team at the University of Pennsylvania. Many sites that intended to use electronic transfer switched to on-line usage when they understood the enhanced functionality that was available, such as the convenience of including lot number information, vaccine inventory update, the ability to print an immunization history and a report of next immunization due for the patient at exit, and immediate update of the data base. Eventually, it also will be possible to have data entered into the registry at point of service and "pulled" from the registry to the provider's billing system using an HL7 interface. This will give the sites all of the point-of-service functionality described above and will eliminate the need to rekey the procedures for billing.

Conclusions

The health care marketplace is changing rapidly with regard to the manner in which health services are delivered and how they are reimbursed. Under the fee-for-service method of reimbursement, measurement was made of utilization of services; in a managed care system, the emphasis is on outcomes, quality of care, and customer satisfaction. Age-appropriate immunization coverage of children is not only a key component of public health, it is an accepted measure of quality for health insurance plans.

Many of the information systems in hospitals and clinics cannot support the new requirements of reporting and measuring for managed care. Major investments are now being made to reengineer and even replace these systems with newer, standards-based technologies and architectures. There is more acceptability of the use of the Internet in health care settings.

The public health goal of the immunization registry is to bring public health standards for age-appropriate childhood immunizations into the practices of clinicians who provide the immunizations. Traditionally, public health information systems (where they existed) lagged behind technologically and were unattractive to providers, especially in private settings.

NJ-CIP approached the development of the registry with the same long-term strategic technology planning that is done by a large corporate enterprise. We had the benefit of a pilot period to test, select, and refine our technology choices and deployment options. These strategic directions have placed public health in a leadership role, positioned to participate as a full partner with hospital, health care systems, and managed care and in larger health information initiatives, such as Community Health Information Networks (CHINs).

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