Biomedical Informatics Unit (BMIU): Slim-Prim System Bridges the Gap Between Laboratory Discovery and Practice

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Abstract

With current national emphasis on translational research, data exchange systems are needed that bridge basic science and clinical research. To meet this challenge, an electronic system was developed by the Biomedical Informatics Unit (BMIU) of the University of Tennessee Clinical Translation Science Institute (UT CTSI). This integrated data system collects, processes, archives, and distributes basic, clinical, and translational research data. The system provides information via web-based applications in a secure and Health Insurance Portability and Accountability Act (HIPAA)-compliant manner to facilitate data sharing and analysis across domains. The system is currently in use by a number of studies and has proven to be an effective tool for data collection and processing in clinical studies.

Keywords: translational research, clinical trials, computers

Introduction

As in any other research community, basic and clinical studies at the University of Tennessee Health Science Center are conducted simultaneously but independently. Providing access to and awareness of others' studies may affect experimental design and clinical application of the resulting data. Implementation of best practices for study design and data collection and sharing will enhance the quality of health care and accelerate progress in biomedical sciences. To address these data integration issues, an integrated data system was developed, called the Scientific Laboratory Information Management and Patient-care Research Information Management system (Slim-Prim), by the Biomedical Informatics Unit (BMIU) at the University of Tennessee Clinical Translation Science Institute (UT CTSI).

Scientific and clinical research databases contain large amounts of data whose format may not always be known in advance. The Slim-Prim system uses an open-source content management system, ContentNOW (Free Software Foundation, Inc., Boston, MA, USA), that employs a row-modeling structure rather than a conventional column-modeling structure. Using concept mapping, the row-modeling design has shown promising results for assembling data from different formats and sources into a centralized system. Slim-Prim employs a metadata-driven system (*Figure 1*) containing standardized data elements and vocabularies such as Systemized Nomenclature of Medicine–Clinical Terms (SNOMED-CT) and International Classification of Diseases codes (ICD9). Controlling these structures and their content enforces controlled data practices. The attributes in the metadata are designed to handle data in various formats (e.g., text or images) and contain the identification keys necessary for data storing, searching, and sorting. The attribute values are stored in a table based on data types specified in a metadata table. All the attribute descriptions and values can also be linked together with related identification keys. An example of the metadata-driven domains and models is shown in *Figure 2*.

The ultimate goal of Slim-Prim is to create scientific and patient care information tools for data collection and entry, storing and retrieval, and searching and sorting and to handle data in various formats. The Slim-Prim system can assist in recruitment of patients as well as in facilitation of data collection. Data can be entered,

viewed, searched, and sorted using web-based applications. The system was designed to be robust and expandable to allow inclusion of clinical data via the Prim system. The system allows collaborators to share data across studies in a uniform way and also supports complex queries targeting specific data sets. For example, the system can store the inventory of reagents and laboratory equipment across the campus as well as assist in managing the data generated from all core facilities. Currently, Slim-Prim supports several clinical studies that are highlighted below.

Subject Recruiting and Research Subject Screening Tool

This clinical trial screening tool identifies suitable subjects, allowing a recruiter more time to speak with potential participants. The screening tool is essentially a confidential questionnaire prequalifying subjects according to the criteria provided by the clinical investigator and is available 24 hours a day. Because Slim-Prim contains options for including adaptive conditions when developing each form, nonqualifying subjects can be screened out rapidly, allowing recruiters to concentrate their efforts on more likely subjects.

Slim-Prim as a Content Management System for Basic and Clinical Sciences

In addition to the subject recruiting forms, the Slim-Prim system includes a repository for genetic, environmental, and lifestyle data and tools to assist in basic data analysis. The Slim-Prim application for this study includes multiple features to collect patient information and incorporate this into demographic data and other surveys. These forms and features can be easily adapted for future studies (*Figures 3 and 4*).

Integration with Electronic Medical Records and Tissue Repositories

The BMIU is currently collaborating with investigators to develop databases that link patient electronic medical records in area hospitals with tissue pathology data. Implementation of the National Institutes of Health [(NIH) Bethesda, MD, USA] “caTissueSuite” on the Slim-Prim server will allow us to federate deidentified data at a national level in the future.

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Figure 1. A schematic outlining the Slim-Prim system. Data from existing sources (listed on the left) can be migrated into Slim-Prim (Oracle database). Controlled information sharing is then possible via the application programming interface (API) with the research community.

Figure 2. A schematic diagram depicting the metadata-driven domains of the Slim-Prim integrated database system (IDS). Controlled vocabularies and a relational database structure allow input to Slim-Prim from multiple formats. Standardized reporting tools allow controlled data sharing and future federation with national resources, such as the NIH caBIG.

Question Number	Name	Description	Type	Method	Required	Action
1	dob	Enter the patient's date of birth:	date		yes	edit delete
2	sex	Enter the sex of the patient:	text (short)	radio	yes	edit delete
3	race	Enter the patient's race:	text (short)	free entry	no	edit delete
4	ethnicity	Patient's ethnicity:	text (short)	free entry	no	edit delete
5	religion	Patient's religion:	text (short)	free entry	no	edit delete
6	clinicaltrial	Patient part of a clinical trial?	text (short)	checkbox	no	edit delete
7	dateofdeath	Date of death:	date		no	edit delete
8	utci_id	Patient's UTCI ID?	text (short)	free entry	yes	edit delete
-	methodist_id	Does the patient have a Methodist MRN? If so, enter here:	integer	free entry	no	edit delete

Figure 3. A screenshot of the Principal Investigator (PI)/administrator interface. This utility allows investigators to construct forms or questionnaires (shown in this figure). Questions can be added individually, or the questionnaire can be constructed offline in an Excel (Microsoft Corp., Redman, WA, USA) template and imported.

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Figure 4. Screenshot of a questionnaire that is visible to the end user (patients, nurses, etc.). Options to enter data via dropdown menus (not shown), radio buttons, and free text entry options are determined by the PI/administrator interface.

Attribute Name	Description
recnum	HCUP unique record number
age	Age in years coded 0-124 years
ageday	Age in days coded 0-365 only when the age in years is less than 1
agemonth	Age in months (when age <11 years)
bwrt	Birth weight in grams
race	Race
female	Indicates gender for KID beginning in 1998
zipinc_qrtl	Median household income quartiles for patient's ZIP code. (estimates are updated annually)
pl_nchs2006	Urban-rural designation for patient's county of residence
amonth	Admission month coded from (1) January to (12) December
recnum	HCUP unique record number
asource	Admission source
asourceub92	Admission source (UB-92 standard coding) (atype=4 or not equal 4)
asource_x	Admission source, as received from data source using State-specific coding
atype	Admission type
aweekend	Admission on weekend
hospbirth	Birth diagnosis, in this hospital
uncrbirth	Normal, uncomplicated birth in hospital
elective	Indicates elective admission

Figure 5. A screenshot of the “data dictionary” from the HCUP KID database module in Slim-Prim. Slim-Prim contains controlled vocabularies such as ICD-9 codes and has a user-expandable dictionary to aid in querying and merging data.

Data Aggregation from Multiple Systems into Slim-Prim

The Slim-Prim system supports data migration from other database systems and transforms the data into standardized formats, allowing researchers to review data in different ways according to their needs. For example, the BMIU has migrated data for the Division of Pediatric Surgery, which currently uses the Kids' Inpatient Data (KID) from the Healthcare Cost and Utilization Project (HCUP) (<http://www.ahrq.gov/data/hcup/>). Healthcare data terms are stored in a “data dictionary,” allowing users to easily query potentially complicated information (Figure 5).

Clearly, the clinical and translational research communities need web-based applications granting access to data and allowing data sharing across laboratories and institutions. Such tools must be strictly designed with research compliance and security in mind; thus, robust levels of access are key components of the Slim-Prim system. This system also uses patient care information tools such

as online screening forms, online applications, and medical forms, as well as the patient's folder containing demographic, laboratory, and historical data. Importantly, Slim-Prim can be adapted to store radiology and image file data, rehabilitation data, and DNA sequencing files. All of the modules implemented within Slim-Prim are active in their own domains, and many have begun to work across boundaries. In addition, integration of the Slim-Prim into other data sources such as the regional health information organization (RHIO) by the MidSouth ehealth alliance (<http://www.midsoutheha.org>) will likely provide an added value to the clinical and basic science researchers in the community.

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