The impact of IAIMS at Georgetown: strategies and outcomes*†

By Naomi C. Broering, M.L.S., M.A.
Director, Biomedical Information Resources Center, and
Medical Center Librarian

Helen E. Bagdoyan, M.L.S.
Associate Librarian, Planning and Database Development

Dahlgren Memorial Library
Georgetown University Medical Center
3900 Reservoir Road NW
Washington, DC 20007

Integration of multiple information systems of a medical center will change the way physicians work and practice medicine in the future. Several major steps must be taken by an institution to make this a reality. Since 1983, Georgetown has been engaged in an Integrated Academic Information Management System (IAIMS) project to bring together multiple sources of information that reside on different computers and database systems. Georgetown is developing a Biotechnology and Biomedical Knowledge Network that includes informational and clinical databases, scholar workstations, instruction on computer use, a campuswide network with local area network nodes, and a modular approach to systems integration. The IAIMS project, spearheaded by the medical library, has enabled a broad spectrum of health professionals to benefit directly from new, dynamic information services. The network is heavily used; in 1991, more than 2,100 individual users conducted more than 148,500 computer functions and more than 104,000 searches. There is economy of scale in high-volume use. Overall, the average search cost is $1.57; for high use databases the cost is $0.38, and for low use, it is $9.41. As described in this paper, IAIMS offers a cost-effective means of enhancing patient care by improving information services to physicians. At Georgetown, IAIMS has advanced the concept of integration, accelerated use of computers in education, increased user acceptance of advanced technologies, and established cost factors for providing information resources. While progress made in improving the transfer of medical information is impressive, it is clear that IAIMS requires several more years of support to achieve full implementation.

At George Town, in the suburbs, there is a Jesuit college; delightfully situated, and, so far as I had the opportunity of seeing, well managed. Many persons who are not members of the Romish Church, avail themselves, I believe, of these institutions, and for the advantageous opportunities they afford for the education of their children. . . .

Charles Dickens, American Notes, *1842*

In 1983, Georgetown University accepted the challenge to plan, develop, and implement an Integrated Academic Information Management System (IAIMS). A project of the magnitude of IAIMS was envisioned to take a decade or more and was estimated to cost more than $25 million to develop an appropriate

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framework and workable environment. The risks were great for early pioneering institutions, such as Georgetown, because the IAIMS concept was untried and there were no models to follow. Georgetown needed to select paths that minimized risks and had a high success potential. To gain credibility, the IAIMS concept needed to move from strategies to actions and this required key resources, core support services, useful information systems, and enthusiastic users with tools and skills to test a model adequately.

What then, does it take to implement an IAIMS that will meet current and future information needs in medicine? What makes an IAIMS project successful? What can be considered useful outcomes? What is the best approach for system integration? Since the beginning of the program, these questions have been asked repeatedly by many institutions. The answers are not simple because much depends on the institutional environment and the organization's capabilities to undertake and address the key factors of IAIMS. However, there are pertinent observations and conclusions about the Georgetown IAIMS that can be shared with institutions planning to launch a long-range undertaking of this magnitude.

Highlighted in this paper are successful strategies undertaken by Georgetown to implement IAIMS and tangible outcomes that have affected the daily activities of health professionals at Georgetown.

BACKGROUND

The purpose of the Georgetown IAIMS is to create a medical decision support system by bringing together multiple sources of information that reside on different computers and database systems. The foundation was built in the IAIMS Phase I Strategic Plan, designed during Phase II Model Development, and expanded currently in Phase III Implementation. The major goal of the Phase III program is the creation of a Biotechnology and Biomedical Knowledge Network consisting of core information resources scattered throughout the medical center and brought together into one electronic system.

The Knowledge Network places a major emphasis on a distributed approach to information access and transfer. Key features include a communications backbone, interface software, and network architecture. Because of this distributed approach, it has been possible to link two major medical systems at the medical center, which are developed independently, managed separately, and based on different hardware platforms and software applications. These include the Library Information System (LIS), and the Hospital Information System (HIS). Plans are to link other systems later.

What solutions are there for the overwhelmed and overloaded information-seeker? New computer technologies complement the medical practitioner's search for the right information at the right time for clinical problem solving and medical decision making. The key is to create the right blend. For students, the Knowledge Network is an opportunity to use computers as memory extenders for clinical problem solving and eliminate the need for intense memorization. For clinicians and researchers, it is a means of accessing a range of information, whenever it is needed—home, office, hospital, or laboratory.

IAIMS STRATEGIES

Today, the IAIMS concept has been accepted as one of the major challenges in medical informatics. The process of functional integration and synthesis of clinical, bibliographic, and knowledge systems has become a major goal of many medical centers. This is happening because the rapid growth of medical information and knowledge has made medical decision making immensely complex.

Because of the increasing investment required to integrate medical systems, it is critical that an institution understand what makes IAIMS a success or failure. Recommended criteria cited in the literature emphasize an IAIMS infrastructure with administrative support, institutional hardware, human resources, and talented leadership to carry out the program [1–3]. The most significant criteria for the Georgetown strategy are organizational structure, academic mission of the institution, knowledge network, systems integration, core support services, and technical resources.

I. Organizational structure

The issue of an IAIMS organizational structure is more than placing the project in a department and giving it an administrative nod to see if it materializes. The project must be placed at a high level and have effective leadership. The major ingredients are administrative support and dedicated project management.

A. Administrative support. A key component of IAIMS is an administrative commitment that comes from understanding the need and appreciating the advantages that systems integration will bring to the institution. It requires a willingness by administration to make an initial long-term commitment with pay-back in the future; hands-on involvement, regular communication with the project director, and periodic reviews of project achievements; providing ideas and essential information about the institution's goals and objectives to help IAIMS crystallize into a useful strategic weapon for the institution; bringing together key internal and external advocates who support, recognize, and encourage the project partic-

ipants; and opening the right doors to attract financial support.

At Georgetown, the medical center library and Biomedical Information Resources Center (BIRC) are the focal points for the IAIMS project. Organizationally, the medical center librarian, who is the project director, reports to the executive vice-president of the medical center, along with the deans and hospital administrator. Regular meetings take place where top-level executives review project status and resolve important issues concerning future directions. The IAIMS project is visible and recognized by the university president; the board of directors; and the deans, administrators, and department chairs of the medical center.

B. Project management. IAIMS requires responsible leadership of a key individual with the authority and capability to put ideas into motion and to achieve project goals and objectives. The leader must be visionary, flexible, respected, responsible, and able to keep the project on focus. The leader must serve as a catalyst who assigns responsibility for project modules and distributes resources equitably to the team participants. Rarely are there sufficient funds to support fully every project the team wants to undertake. Difficult decisions have to be made and an atmosphere of fair play, trust, and team spirit is essential for success.

To address these critical factors, Georgetown appointed an IAIMS Management Committee of key players from all units of the medical center, including the Schools of Medicine and Nursing, the hospital, the Cancer Center, and representatives of major clinical and basic science departments involved in the project. This committee has been aided and supported by an IAIMS executive board of nationally recognized health and information leaders, external to Georgetown [4]. The IAIMS Management Committee, chaired by the project director, meets monthly with the senior faculty leaders who are responsible for subprojects to review progress. An IAIMS Technology Laboratory, funded by the project grant and based in the library, provides technical support, maintains the IAIMS computer and network systems, designs software, and implements databases for medical center users. The library staff in BIRC provides training and education support.

II. Academic mission of the institution

An essential component for project success is compatibility with the academic mission of the institution. By strategically positioning IAIMS closely to the mission of the institution, the project is tied to executive goals and objectives. The institutional mission must be consistent with IAIMS planning and project emphasis. This explains why IAIMS can be different at each medical center.

The mission of the Georgetown University Medical Center is to develop new knowledge about disease and, through this, to provide patient care and teaching. It firmly incorporates the tradition of research, patient care, and education. The library plays an essential role in creation of new medical knowledge. Because of this mission, the IAIMS project emphasizes academic information and development of a knowledge network to support the special focus of the medical center's programs. There is a strategic alliance of three critical factors at the Georgetown IAIMS: the organizational structure, academic mission, and focus of the Knowledge Network.

III. Knowledge Network

The exponential growth of medical knowledge has created a major problem in medicine. The information needed to support education, research, and patient care is becoming increasingly complex and unmanageable. IAIMS requires a strategy for meeting these rapidly changing and growing needs by packaging information in an easily accessible manner for users. Obviously, maintaining all forms of biomedical information within the institution is prohibitively expensive. By carefully selecting areas of institutional emphasis, an IAIMS project can concentrate on supporting knowledge databases that enhance its programs. Other special needs can be met by providing network access to resources outside the institution.

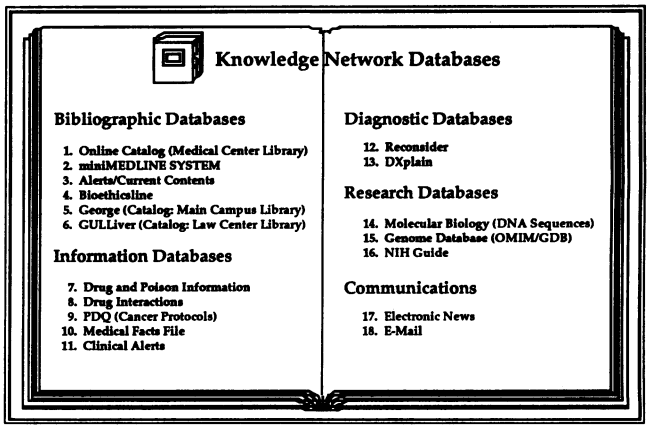
The Georgetown strategy is to develop the Biotechnology and Biomedical Knowledge Network in a modular fashion and add selected biomedical databases that have universal applicability to campus users [5]. The Knowledge Network with its bibliographic, informational, research, and clinical databases combine to form a medical decision support system that has a strong following and serves an immense need. The idea of providing free access to resources, offering core support services, seeding IAIMS components in various units and departments, and teaching users how to access the Knowledge Network for their daily work has proven successful. The medical center's sophisticated LIS and HIS systems play a key role in the project. Special business, hospital, and high-tech computer research projects in the medical center reside in their unique departments. Most notable are the Image Management and Communications System (IMACS) project in the Department of Radiology and the Molecular Biology, Protein Sequence, and Digital Imaging Projects of the National Biomedical Research Foundation (NBRF) in the Department of Physiology and Biophysics.

A. Biotechnology and biomedical databases. The information resources of Georgetown's Knowledge

Network are organized into a manageable body of IAIMS databases and systems. The single access menu includes a family of bibliographic, informational, diagnostic, and molecular biology databases. The library manages and maintains all these databases except the patient care systems, which are maintained by the hospital and individual clinical departments. Arrangements have been made with HIS, IMACS, and NBRF to tap their resources.

Figure 1 contains a list of the databases available for users of the Knowledge Network. The group of bibliographic databases provides three types of information: references to the library's print and nonprint collections, article references with abstracts, and full-text articles and books. The information databases are factual systems covering a wide range of subjects such as drug and poison information, cancer protocols, publishing information, statistical data, normal values, etc. Two diagnostic prompting systems give students an opportunity to establish good skills in differential diagnosis. The molecular biology databases provide researchers with the major international sequence databases, including the Protein Information Resource, GENBANK, and EMBL (European Molecular Biology Laboratory), as well as the GCG (Genetics Computer Group) sequence analysis software for manipulating and interpreting new sequences. The library uses the Electronic News to disseminate information of wide interest, and users communicate with each other through E-Mail [6–20].

Figure 1
Dahlgren Memorial Library Knowledge Network: LIS and IAIMS databases



B. Scholar workstations. Practitioner, student, faculty, and researcher workstations provide user access points to the Knowledge Network. These workstations vary in power and capabilities depending on user needs. Typically, they store local files, maintain dedicated information and software systems, and have access to the network databases.

The practitioner workstation project evolved from the IAIMS model program with the Department of Neurology to automate their patient system. Workstations were linked to the HIS clinical laboratory and radiology to retrieve report results online. These workstations have allowed physicians to maintain their own patient records locally, to use the data to monitor treatment, and to conduct clinical investigations [21]. The neurology system has become a model for projects launched in ophthalmology and psychiatry. Slightly different, because of special needs, are patient database systems being developed in emergency medicine. All the practitioner workstation systems are designed to interface initially with the IAIMS Knowledge Network databases and HIS.

The student workstation is of major importance in the educational program of the schools. Georgetown has developed a multifaceted medical/clinical informatics program that includes student workstations with a variety of resources and learning experiences to prepare today's students for tomorrow. These workstations touch the students' daily life—classroom learning of basic sciences, patient care in the clinical setting, small group instruction during rounds and special clerkships, and self-learning in the library or at home.

Medical students on clinical rotations at the Georgetown University Hospital use MAClinical Workstations on the wards as part of their daily clinical activity. Currently there are more than twenty-five Macintosh machines and printers located throughout the hospital and at clinical teaching sites in several affiliated hospitals. These MAClinical Workstations serve multiple educational purposes. Students gain experience in medical informatics and use the H&P Writer developed by the library to prepare admission records on patients they examine. They can keep patient records, check findings against a diagnostic system, look up drugs, scan treatment protocols, and find information when needed in the medical literature. The MAClinical Workstations are connected to the medical center's local area network with access to the IAIMS Knowledge Network databases [22].

The researcher workstation project began with the implementation of two workstations designed to provide researchers with capabilities for integrated DNA sequencing. It was an experiment to automate the tasks of conducting thousands of sequences in the Department of Microbiology's AIDS Research Laboratory and for projects undertaken in the Department of Biochemistry. The workstations, based in the laboratories, integrate database searching with actual

laboratory experiments. Today, more than 130 researchers throughout the medical center, including the Cancer Center and basic science and clinical departments, are using the molecular biology databases and sequence-matching software. These systems are available to all network users, free of charge.

The faculty workstation is best illustrated by the project between the IMACS and IAIMS programs to develop a teaching component of digitized images in fetal anomalies. This project incorporates the combined capabilities of the IAIMS and IMACS programs. The occurrence of fetal anomalies is low; however, students and residents need experience in diagnosis and management. The faculty workstation concept also has been used by the library to support educational software development projects with the Departments of Physiology, Ophthalmology, Pediatrics, Pathology, Anatomy, Otolaryngology, and Endocrinology.

IV. System integration

It is necessary that academic medical centers consider system integration to help their physicians, researchers, and students cope in today's information age. The magnitude of information systems, technological advances, and equipment investments, coupled with shrinking budgets, make integration not only a necessity but the only logical approach to system efficiency. Pivotal to this is having a well-developed network system.

The AT&T experience of more than fifty years has shown that a single, stand-alone telephone is of little use unless it can be linked to a national network of users. Certainly this has become a universal resource and functional requirement for all modern nations [23]. Similarly, an integrated medical center system is merely the initial step in a series of events destined to make a radical change in the way doctors will practice medicine in the twenty-first century. Imagine a health network linking physicians and researchers throughout the world that will enable them to exchange data and images online, even while they are speaking on the telephone. Georgetown is positioned to move in this direction in the future.

The challenge of achieving system integration at Georgetown without sacrificing the investment of LIS and HIS, two existing sophisticated systems, has been met by using a distributed systems approach. Major links to the institutions' computers are provided via the network, and system integration is being accomplished in a modular manner through enhancements. Users already have seamless access to different mainframes and minicomputers through the network. Software developed in-house facilitates this access and provides transparent navigation among the varied IAIMS databases and HIS components.

A. BioSYNTHESIS. As an initial step to system integration, a single access menu for users has been achieved with the BioSYNTHESIS retrieval system. The various stages of system integration include developing initial linkages, interfacing a few trial databases, adding a family of new databases, incorporating multiple database searching capabilities, adding a medical vocabulary system such as the NLM Unified Medical Language System, and enhancing LIS and HIS to provide users with seamless information transfer. BioSYNTHESIS is a multiphasic project which began in 1987. BioSYNTHESIS I provided a single menu for the initial family of IAIMS databases that reside on different computers. BioSYNTHESIS II is a gateway system expanded to include additional databases and access to external systems via Internet. BioSYNTHESIS III is a long-term development project to create a search engine that facilitates complex searching of multiple databases for the user. A prototype has been designed with semi-intelligent architecture that responds to a user's initial entry terms and searches selected bibliographic databases automatically [24–25].

B. Hospital Information System (HIS). The HIS components relating to systems integration now provide users with the ability to tap seamlessly into the IAIMS databases from hospital workstations. HIS users have a single entry mechanism, similar to BioSYNTHESIS, and functional capabilities of both systems are readily available at the click of an icon.

A five-year project to enhance the HIS system was undertaken by the hospital in 1990. Plans are to achieve an integrated patient care information system (PCIS) that functions as a virtual database of all patients seen at Georgetown. The magnitude of this data may require the use of optical disk technology for storage. The goals of HIS complement those of IAIMS with the integration of the medical record, hospital systems, and the Knowledge Network resources being implemented so users can conduct their medical work in a one-step process.

V. Core support services

Core support services, as expressed by Wilson, are vital to achieving a successful IAIMS program [26]. There must be a unit in the medical center responsible for providing technical support, giving consulting assistance on major hardware and software systems, implementing a network system, and training institutional users. Implementing a network system is extremely expensive, and a variety of funding approaches can be followed by institutions. However, the success of IAIMS depends heavily on imple-

menting strong core support services that include a network system. These services must include access to databases, provision and maintenance of computers and networks, support of educational services, and a variety of programming services for key projects.

The approach of the Georgetown IAIMS is to provide these basic core support services including free access to the in-house Knowledge Network databases and to seed educational projects in departments that propose viable IAIMS subprojects. Because of these services, the library has emerged as a medical academic computing center. The combined efforts of library personnel, including BIRC and IAIMS Technology Laboratory staff, constitute the core support service team [27].

A. Teaching computer use. To adopt information technology successfully and begin an IAIMS-type program at an institution, mechanisms need to be established to educate users so they can benefit from the numerous resources available to them. At Georgetown, the BIRC librarians provide training on use of the IAIMS network, information access skills, use of computer-based education programs, and basic use of personal computers. In addition, consulting services are provided on database development, personal information management, and use of factual databases and expert systems for medical decision making. Reference librarians also play a significant role in teaching information access and database use.

BIRC has more than 400 microcomputer software programs and multiple copies of popular software. There are approximately eighty workstations and two computer classrooms in BIRC. The BIRC staff work with faculty to encourage educational software development. Several pertinent and exciting medical informatics projects have emerged from joint ventures with the School of Medicine. Recent additions are the Electronic Textbook in Human Physiology Project, funded through a U.S. Department of Education grant awarded to the library, and a Microanatomy Digital Slide Library, supported with in-house resources.

B. IAIMS technology laboratory services. As the IAIMS program evolves, a successful working strategy using subgroup teams for project implementation has emerged. The IAIMS technical staff are assigned to work on special project components with medical center librarians and faculty. Initial planning and brainstorming sessions are held, a calendar is then established with target deadline dates, tasks are assigned, follow-up meetings are scheduled, and incremental steps are established for a phased approach to implementation [28].

VI. Technical resources of the institution

To develop an IAIMS megasystem requires large budgetary expenditures, time to design and implement a system, and flexibility to utilize dynamic technological changes that occur. This is why a modular approach is a viable solution for IAIMS institutions, as long as integration is addressed. This approach also makes subprojects manageable and affordable. There are two technical capabilities required for an IAIMS: a network architecture, including communications and computer systems architecture, and highly trained technical staff.

The IAIMS grant from NLM has been invaluable in providing technical staff salaries and equipment support for the project. In addition, equipment grants have been awarded to Georgetown from AT&T, Apple Computer, and Digital Equipment Corporation, and an AT&T Foundation grant supported initial work on the BioSYNTHESIS project.

A. Network architecture. The Georgetown University-wide network, described by Bagdoyan and Hylton [29-30] encompasses three major components: IAIMS, the hospital, and the university. The university uses an AT&T telecommunication system as the backbone system with AT&T ISN nodes for electronic transmission of data. The IAIMS communication network includes two AT&T ISN nodes, which were the first local area network systems to be implemented at Georgetown. The IAIMS network supports more than 500 end points throughout the medical center. This, coupled with the university network that supports approximately 1,600 asynchronous and synchronous connections and the hospital's Sytek system, a broadband network that has 1,100 end points, provides a powerful bridge and pathway for the IAIMS project. Users can gain access to the network from home, office, or campus, and also they can use the gateway to access external systems.

B. Technical staff. The IAIMS technical team of twenty experts includes librarians, information specialists, system/programmer analysts, and electronic technicians who work under the guidance of the IAIMS project director. Approximately ten team members are funded by the IAIMS grant: eight computer scientists based in the IAIMS Technology Laboratory, BIRC, HIS, and IMACS who develop software, manage the IAIMS computers and networks, and design peripheral support systems, and two librarians who work on database development and training.

IAIMS OUTCOMES

Every facet of health care delivery, education, and research at the Georgetown University Medical Cen-

ter has been affected by the implementation of the IAIMS program. This is evident in the way physicians and nurses care for patients on a daily basis, how health professions students are taught and what they learn, which databanks are in high demand by the bench scientists, the variety and complexity of information resources provided by the library, and the manner in which the medical center's major computer systems link and share information.

The IAIMS program helped to wake the sleeping giant of the 1980s, the "information decade." During the past ten years, astonishing changes have occurred in the way health professionals at Georgetown access, store, manage, and create information. IAIMS has been a powerful change agent; it has served as a catalyst and facilitator by creating an awareness of the need to implement information technology and by showing that integration of various institutional information resources can be achieved.

Tangible outcomes of the IAIMS program can be viewed from several perspectives, all of which combine to have a direct impact on the way information is transferred and utilized at Georgetown. IAIMS has served to

- advance the concept of integration;
- accelerate the use of computers to enhance education;
- increase user acceptance of advanced technologies; and
- establish cost factors of providing information resources.

I. Concept of integration

Implementation of the IAIMS Knowledge Network was instrumental in successfully advancing the concept of integration at Georgetown. Yesterday's information-seeker had to rely on a personal arsenal of telephone numbers, access codes, log-in procedures, and searching strategies. Today's information-seeker, because of IAIMS, is guided through the network and navigated from database to database and system to system in a seamless fashion. A users's effort is spent in using the information, not looking for it. Through a single entry point, the network provides users with a wide range of information resources. Diverse technologies, different databases, and disparate systems are linked in a distributed approach so users of the network have access to resources that transcend previous barriers of time, geography, ownership, hardware platforms, and software applications.

Integration has improved access and utilization of resources and has served to promote institution-wide sharing of information. In 1983, for example, links to the HIS and the three campus libraries were nonexistent. Furthermore, system managers feared that a single point of entry endangered database integrity and security. Today, there is greater interest in improving the flow of medical information and maintaining an intrinsic relationship between clinical, education, and research information. Today, users can navigate freely through the institution's resources to get patient test results, look up treatment modalities, access the latest medical literature, and make improved diagnoses. Making informed medical decisions is the critical payoff for patients. The physicians understand and value this; that is why IAIMS has such a strong following at Georgetown. As information becomes easier to obtain through programs like IAIMS, we will experience vast improvements in the delivery of patient care.

II. Enhancements to education

Forceful statements calling for a major change in the nation's health care educational system have been made by four major organizations: the American Association of Medical Colleges in the Report on General Professional Education of Physicians (GPEP); the National Board of Medical Examiners' announcement to implement computer-based testing in Part III of the national examinations; the Association of Academic Health Centers' (AAHC) report, "Executive Management of Computer Resources in the Academic Health Center"; and the Pew Charitable Trusts' recent report, "Health America: Practitioners for 2005" [31–34]. Basically, these studies challenge educators to transform education and emphasize problem solving over traditional memorization approaches in classroom teaching.

The most visible impact of IAIMS at Georgetown can be seen in the enhancements to health education. Computers acquired through IAIMS funds are used as memory extenders to shift the education focus from memorization to information access. We have implemented a successful program for future health professionals, as well as researchers, faculty, physicians, nurses, pharmacists, and allied health specialists to use computers and communications systems increasingly to conduct their daily tasks. Without IAIMS support, Georgetown would not have made such noticeable strides.

The educational change begins at computer workstations in the library, BIRC, and the MAClinical stations in the hospital. A variety of knowledge resources and learning experiences acquired at these workstations has permeated classroom learning in the basic sciences, patient care in the clinical setting, small group instruction during rounds, and self-learning in the library or at home. The information tools available to students for solving assignments or clinical problems are different today than they were prior to IAIMS, and this affects the learning process and required skills. To provide these new skills, George-

town has developed a teaching program that embraces the IAIMS-supported Knowledge Network of major information resources and databases. The network's one-step approach of navigating from one system to the next has changed the education paradigm in an evolutionary manner.

During this process, the role of the library and the librarians has shifted dramatically. While the teaching responsibility for subject content is the primary domain of the faculty, a new instructional role, that of teaching the mechanics of information management, access, and retrieval, resides with librarians. For physicians-in-training, learning to navigate through information systems to manage knowledge is as essential in the curriculum as course content. Another responsibility assumed by the library is teaching students to conduct clinical education tasks involving medical decision making, such as preparing automated histories and physicals of patient encounters, manipulating diagnostic systems to learn differential diagnosis, looking up drugs, and determining options for treatment modalities.

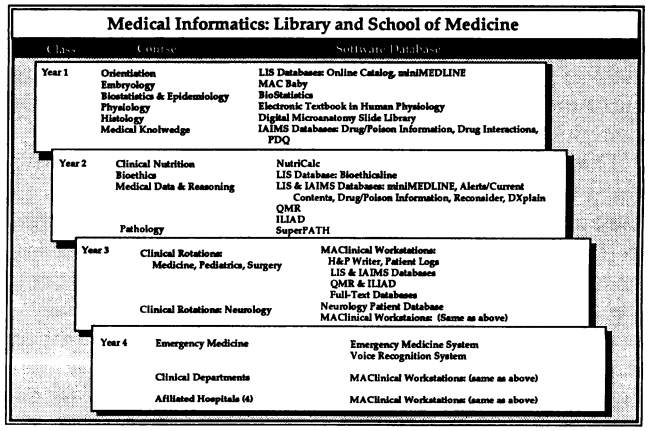
Nowhere at Georgetown is acceptance of IAIMS in education more apparent than in its "electronic library." IAIMS has contributed to a change in mindset about the library's role in information management. The integrated approach of replacing the card catalog with the online catalog, the inhouse bibliographic search systems such as the miniMEDLINE SYSTEM℠, ALERTS℠/Current Contents, Bioethicsline, and the recent trend toward delivery of full-text articles of medical literature directly to the clinical learning sites, have revolutionized the way students learn to use library resources. Today, because of IAIMS, the library is not as concerned about the number of users entering the library as it is about providing electronic access to its knowledge databases and teaching users how to find information electronically both within and outside the library.

By introducing the IAIMS-supported programs, Georgetown has added a medical informatics dimension to the curriculum. As students progress through the four-year curriculum, they gain the following computer competence:

- basic computer literacy,
- use of educational software to grasp major basic science concepts,
- bibliographic searching of the medical literature to solve clinical problems,
- use of information and diagnostic systems to complete patient care assignments, and
- preparation of automated history and physical reports on patient encounters.

Instruction on use of electronic systems to retrieve information is provided to students with varying levels of computer sophistication. Several classes have been transformed to include computer use with resources made available through the IAIMS program. IAIMS is responsible for accelerating both the process and acceptance by students and faculty. It has enabled Georgetown to coordinate educational software and hardware resources, develop medical information systems to support the curriculum, and support instruction on the use of computers.

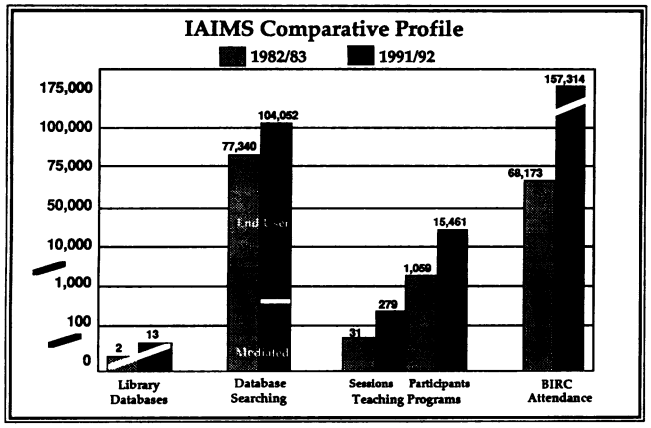
Figure 2
Medical Informatics: combined participation of the library and the School of Medicine



In the School of Medicine, basic computer instruction is part of the required freshman orientation given by the library, and computers are integrated into eight required courses in the first and second years and into four major clinical clerkship rotations in the third and fourth years—medicine, surgery, pediatrics, and neurology (Figure 2). In addition, there are informal short courses and an elective on computer use available to students. Very little of this existed prior to IAIMS.

In the basic sciences, IAIMS has sponsored the development of software programs to provide students with supplemental learning resources. Projects that have provided visualization of the human system, leading to a better understanding of complex functions of the body, have been given a high priority at Georgetown. These include the SuperPATH system, which integrates digitized microscopic and gross pathology images with lecture notes, glossaries, and explanatory text; a Microanatomy Digital Slide Library, developed by IAIMS staff, of sixteen laboratory exercises and more than 500 images to support a histology course; and the Electronic Textbook in Human Physiology, funded by a library grant from the Department of Education and also supported by BIRC's computer classroom and staff. The electronic textbook incorporates the multimedia approach to learning by

Figure 3
IAIMS impact at Georgetown: a profile of change



combining text, animation, sound, and graphics in cardiovascular, endocrine, and renal physiology.

In the clinical sciences, IAIMS began by introducing the MAClinical Workstations to transform the way students manage and access information. Through these twenty-five workstations, students have gained skills and information query habits they will use in their future medical practice and in their daily clinical activities as physicians-in-training. They have learned to use various resources including miniMEDLINE to solve patient care problems. Another result of the MAClinical project is the ability to track the type of patients seen by the third-year medical students on each clinical rotation.

In 1990, the School of Medicine introduced a new course, "Medical Data and Reasoning," to prepare second-year students to solve clinical problems. According to the associate dean for undergraduate education, this course would not have been possible without support from IAIMS. The course introduces students to various medical informatics systems and software developed in-house. Resources acquired through IAIMS in a number of cooperative projects with other institutions provide basic software that supports this course. Two diagnostic systems, RECONSIDER (University of California at San Francisco) and DXplain (Massachusetts General Hospital) are accessible to students through the IAIMS Knowledge Network. Individual workstations in BIRC and the hospital have two expert systems, Quick Medical Reference (QMR), developed at the University of Pittsburgh, and ILIAD, developed at the University of Utah. Both of these systems operate in a textbook mode for reading the knowledge base, a consultation mode for generating advice on patient workups, and a simulation mode where students attempt to reach a diagnosis on a simulated patient by ordering tests. Georgetown is attempting to couple these diagnostic databases with the H&P Writer program developed for the MAClinical Workstations to enable students to enter initial patient histories, receive printed write-ups, have access to the expert system consults, and conduct literature searches for probable diagnoses.

III. Acceptance of advanced technologies

An obvious impact of the IAIMS program is the way it has transformed the information behavior of Georgetown's health professionals: faculty, students, and staff. Because of the information resources available through IAIMS, there is a noticeable interest in learning how to incorporate computers in daily activities, how to develop information access skills for life-long learning, and how to search and retrieve medical literature. Despite a stable user clientele, literature searches and use of library materials have experienced phenomenal growth.

Acceptance of advanced technologies is evident by the immense growth and use of the network databases, and increased enrollment in the library's computer courses. Significant increases have occurred in these areas during the nearly ten years of IAIMS at Georgetown (Figure 3). In 1982–1983, there were only two bibliographic databases available to users: the Dahlgren Online Catalog and the miniMEDLINE SYSTEM. By 1991, there were thirteen databases on the Knowledge Network and the choices extended beyond bibliographic searching to informational, diagnostic, and full-text databases. During this time frame, users have become comfortable with self-service searching. User searches of the Knowledge Network databases have increased by 35% while librarian-mediated searches have decreased dramatically (69%).

The teaching role of the library emerged with the proliferation of new databases. Librarians were viewed as information experts who could instruct users on database searching, microcomputer use, and information access. In 1982–1983, the library's teaching program offered thirty-one courses and orientation sessions to more than 1,000 attendees. By 1991–1992, the library conducted 279 formal sessions of classroom courses, seminars, and orientations, as well as individual tutorials for point-of-use instruction, for more than 15,400 users. Figure 4 lists the variety of instructional courses the library provides in its IAIMS program, including teaching information access skills and use of the Knowledge Network databases, microcomputer use, and special software applications. Of the thirty-two courses offered currently, some are specific to a particular database and discipline; others

Figure 4
IAIMS teaching programs: library-sponsored

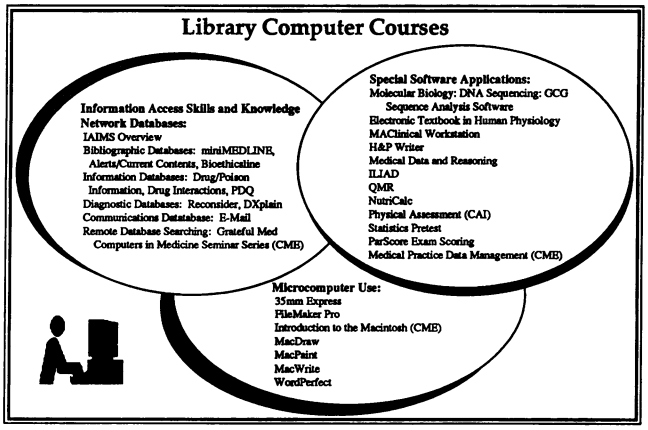
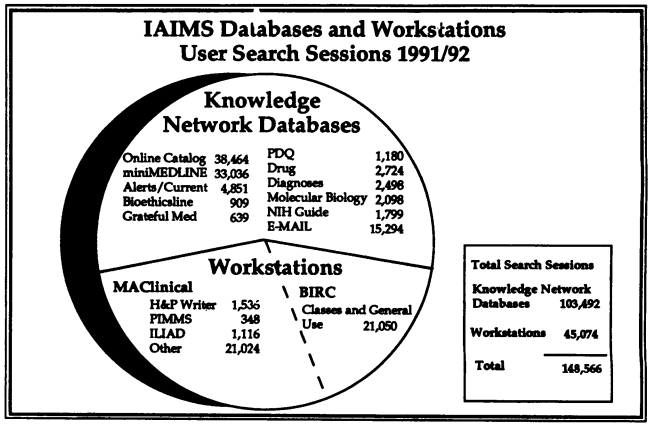


Figure 5
IAIMS use of databases and workstations: 1991–1992



provide a broader sweep and combine educational software resources and database searching.

One of the most significant changes from an educational perspective is the willingness of faculty to integrate computers in their courses and to participate in developing educational software and computer-assisted instructional programs. Some faculty have been willing to invest their time to develop educational software now that peer review committees are more receptive about acknowledging the scholarly merits of these products.

The core support services sponsored by IAIMS and provided by the library staff are heavily subscribed to by the medical center community. In recent years, attendance in BIRC has jumped significantly from a total of 68,173 persons in 1982–1983 to more than 157,000 in 1991–1992, consultation services on network technology have increased, and database development instruction is growing. Use of the scholar workstations continues to increase considerably, and the number of searches conducted on all the Knowledge Network databases has climbed to record proportions. Figure 5 attests to the popularity of the IAIMS Knowledge Network databases.

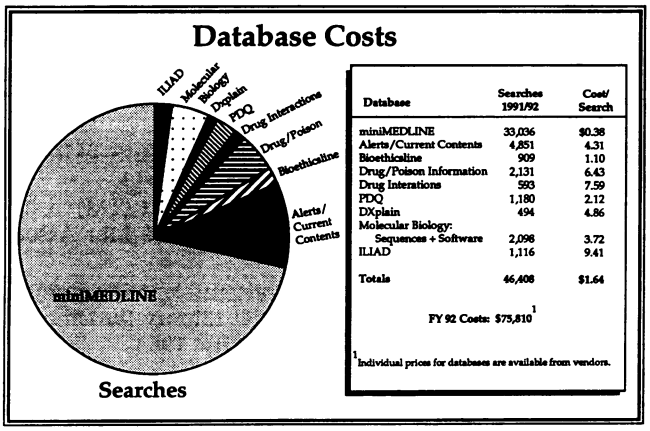
One might argue logically that statistics on system use do not necessarily enhance patient care unless direct impact can be shown. While a few individual incidents portraying immediate patient care results can be cited, the sheer number of searches and users accessing the Knowledge Network on a daily basis is an important indicator of usefulness that cannot be denied and must be considered. On an average day, more than 200 users log into the network. In 1991 more than 148,500 computer log-ons and more than 104,000 searches were conducted by more than 2,100 faculty, nurses, researchers, and students (Figure 5). Data on computer instruction and database use show that more than 15,400 yearly users have participated in some aspect of the library's computer courses. These health professionals, who are extremely busy, devote their precious time to learn and use the network because they receive immense benefits from these IAIMS information resources. Physicians and nurses conduct searches in the literature when they need to resolve a problem or they need new knowledge either to treat or diagnose a disease. Students, who are known for discovering short-cuts, are heavy users of the network because they get immediate results. The researchers, who have traditionally been the heaviest users of the library's recorded knowledge, now actively use the molecular biology databases and DNA sequence systems with increased fervor. Basically, IAIMS offers a fast way to get what they need!

IV. Cost factors of providing information resources

Providing information resources in any format carries a heavy price tag. As institutional budgets shrink and costs for providing information resources rise, it is critical that user demands for information are met with the most essential resources. Just as the health practitioner treating patients needs the right information for clinical problem solving and medical decision making, the library is no different; it needs to provide the right information material at the best price. Choices made must be based on hard data that reflect accurately the information needs of the user.

The IAIMS computer logs provide evidence that the $750,000 grant received from NLM in 1991 enabled Georgetown to improve the transfer of information to enhance patient care, research, and education at amazingly low costs. In 1991, the Knowledge

Figure 6
Database costs



Database	Searches 1991/92	Cost/ Search
miniMEDLINE	33,036	$0.38
Alerts/Current Contents	4,851	4.31
Bioethicsline	909	1.10
Drug/Poison Information	2,131	6.43
Drug Interations	593	7.59
PDQ	1,180	2.12
DXplain	494	4.86
Molecular Biology: Sequences + Software	2,098	3.72
ILIAD	1,116	9.41
Totals	46,408	$1.64

FY 92 Costs: $75,810[1]

[1] Individual prices for databases are available from vendors.

Network logs show that Georgetown users conducted 148,566 computer functions. Without analyzing the specific encounters, because some are more complex and time-consuming than others, the raw data show that each encounter costs approximately $5.05. This is a rather reasonable cost considering the wealth of information and benefits received by each user. These figures do not include use and costs of HIS, IMACS, and LIS, nor do they include the institutional support by Georgetown.

Another important fact is the overall effect of the equipment investment from the grant. The placement of computers in strategic areas throughout the medical center and library has been another cost-effective and efficient way of gaining great benefit from the grant funds. At this point, Georgetown has acquired more than fifty workstations, which have been placed in selected departments, the library, and the hospital for general use by students, residents, and faculty. The average cost of each workstation (computer, color monitor, and printer) is approximately $5,000. However, the volume of use at each of these public workstations is so high (148,566 times in 1991), that we calculate an average cost of $1.68 for each encounter.

With the implementation of online resources in the IAIMS Knowledge Network, detailed use statistics are recorded every time a user accesses a database. The direct costs of providing a database can be examined, matched against use statistics for a specified time period, and analyzed as a measure for return on investment. For example, Georgetown spent $75,810 in fiscal year 1992 to acquire tapes of nine databases (Figure 6). During the year, a total of 48,412 end-user search sessions of the 9 databases were conducted with an average cost of $1.57 for each search session. As expected, the biggest bargain in searching comes with the high-use databases. Over 33,000 miniMEDLINE search sessions were conducted, at a cost of $0.38 per search. One of the more complex knowledge systems with lower use cost $9.41 per search.

Over a period of time, conclusions can be drawn about which databases are essential to the institution's information needs based on use and demand. We are able now to track use statistics and create effective use and cost profiles for each of the resources provided. It has not been possible to have the same depth of detail on use of print resources. Detailed use statistics provide valuable information on high and low use databases, the characteristics of users (their status, discipline, and educational level), numbers of completed searches, the kind of information searched, and even the prime time of system use. With this type of information, the library can begin to measure value. The need to publicize and instruct users can also be judged by studying activity flow before and after publicity campaigns and courses for large groups. Decisions can be made, backed by hard data, on whether it is cost-effective to continue providing an information resource or whether other options should be explored, such as resource sharing. With resource sharing, institutions can broaden their user base, distribute and reduce costs, and create a much better return on investment for all involved.

Another advantage of having good data on actual costs of an information resource is the ability to prepare realistic budgets and set a fair price for information services. Although Georgetown offers the use of databases free to its institutional users today, there is concern about funding this in the future. With use data, it will be possible to set a fair price and to prepare more accurate budget calculations for the costs of information resources.

CONCLUSION

Georgetown's ability to fulfill the IAIMS promise relies heavily on achievements in recent years and the immense work that still needs to be accomplished. Georgetown needed first to develop the Knowledge Network and instruct a body of users before impact of the program could be analyzed. Progress made has resulted in several models that are being used to launch subprojects throughout the medical center. Credibility has been attained by developing an IAIMS following in the medical center. This has been earned by providing users with free access to commonly useful databases, by giving users training and technical support, and by equipping project participants with start-up systems. Much of the progress achieved in integrating computers in education at Georgetown can be attributed to IAIMS support. System integration for improved information access and informa-

tion management has been launched successfully through IAIMS. On the other hand, institutional support for installing a multimillion dollar campus network system has furthered development of the IAIMS Knowledge Network. Without this communications backbone, the IAIMS network would not be accessible. Georgetown has benefited greatly; it has also made a heavy commitment to information technology and this will undoubtedly expand in future years.

As described in this paper, the project is tremendously ambitious and long term. In reality, while the groundwork has been laid, much work needs to be accomplished before full implementation can occur. Computers must permeate the entire institution before all the goals of IAIMS can be achieved. New technologies being introduced need to be incorporated. Georgetown has a good start, but IAIMS must continue beyond ten years to reach the ideal implementation stage. The dream of networking with other institutions on a national system is clearly in the horizon. Already, multi-institutional networking is being implemented among IAIMS institutions. An IAIMS consortium of several universities is providing an initial communication network system for e-mail. It is possible that a major health network will evolve through the emerging NREN (National Research and Education Network) and the High Performance Computing Act recently passed in Congress. Georgetown needs to play a role in this network and to find a means for continuing support for the great achievements of IAIMS.

Has the investment been worthwhile? Have the authors provided evidence of the impact of IAIMS on education and patient care? Is use data available that justifies the funds spent on the program? Do hard data show sufficient value or return on dollars invested? Surely, the answers to these questions are obvious to the reader!

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