

DESIGN OF AN INTERNET-ENABLED HOSPITAL IN THE HOME INFORMATION SYSTEM FOR AMBULATORY CARE

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Abstract –The development of a set of Internet-enabled forms and a relational database management system known as “Hospital in the Home Information System” (HHIS) is discussed. HHIS is an information management and communication system for ambulatory care. Hospital patients who can be treated and cared for in their own homes and do not necessarily have to be based in the hospital are assigned to an ambulatory care program. The ambulatory care program is used to manage post-acute, and acute care at home as an alternative to in-patient care. The HHIS system attempts to bring together both hospital and community based aspects of care to these “hospital in the home” patients.

The aim of the project is to develop a user-friendly, database-driven system accessible via the Internet, which will replace the current paper-based system. The system design and technologies used in the implementation of the system are outlined, along with a brief description of the trialing of the system.

Keywords – Ambulatory care, internet, information management, community care.

I. INTRODUCTION

Hospitals today have to deal with a large amount of information traffic with the need to share information with external systems that are related to the hospital. Such external systems include ambulatory care systems that involve patients receiving specialised treatment and care in their own homes without being admitted to the hospital. Increasingly, home and self-care are becoming cost effective alternatives to in-patient care. The information technology explosion has to a large extent facilitated this shifting of care [1]. The data transferred between such systems have not been managed optimally, as all the work has been done by paper-based systems [2]. As the amount of data increases there needs to be some form of computerized control of the data to give uniformity to the external systems that interact with the current ambulatory care scheme [3,4]. Described herein is the system design and implementation of one such system.

II. SYSTEM DESIGN

The primary function of the Hospital in the Home Information System (HHIS) is to manage the movement of patients who are referred into the system, receive care and are eventually discharged. This task must be done in a manner

that ensures the integrity and security of confidential patient and other information [5]. The design of information flows for HHIS came from an extensive one-year user needs assessment as part of a National Hospitals Demonstration Program. For a patient to enter into the HHIS program, they need to be referred in by either a referring General Practitioner (GP) or a member of staff from the Ambulatory Care Unit (ACU) in the hospital. A special shared care program is then created for the patient, which involves the allocation of nurses from the community to provide home-based care for the patient. The patient receives care from the community nurses, ACU as well as their own GP until the referrer decides to discharge them.

The system is based on referrals. Each referral represents a patient who needs to receive care. A patient can have more than one referral, meaning that they are being treated for more than one problem. However the care administered for all referrals that the patient is under is completed in the one visit.

Each referral will go through a number of states. There are five major states defined in the system:

1) **New Referral**

A referral is just entered into the system,

2) **Awaiting Approval**

The shared care program has been initiated but is awaiting approval,

3) **Care Approved**

The shared care program has been approved and the patient is ready to receive care from the community nurses,

4) **Discharge Requested**

The referrer has initiated the request for the patient to be discharged from the shared care program but is awaiting approval,

5) **Discharged**

The discharge details have been approved and the patient is officially discharged from the shared care program.

The HHIS involves a number of people who interact with the patient and monitor their progress from the initial “New Referral” state to the final “Discharged” State. These people include:

- System Administrator
- Ambulatory Care Unit (ACU) Personnel
- Referring GP
- Primary Health Nurse (PHN)
- Community Care Nurse

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Ambulatory Care Unit Personnel

The Ambulatory Care Unit (ACU) in the hospital is mainly responsible for the creation of new referrals for HHIS patients who need to be placed on the shared care program.

The ACU will also have to approve shared care program details for referrals made by referring GPs. This usually involves someone from the ACU checking the treatment plan, medication form and general care details that the referring GP has requested.

Once the referring GP decides to discharge a patient from the shared care program, they again require the ACU to check the discharge details and approve that it is satisfactory for the patient to be discharged.

When all the users who are required to approve the shared care or discharge details have acted, the referral will change state. For example, a referral made by a referring GP in the “Awaiting Approval” state will change to “Care Approved” after the required users have approved the Shared Care form. Similarly the referral state will change from “Discharge Requested” to “Discharged” once all required users have approved the discharge details.

Unlike referrals made by referring GPs, each referral made by staff from the ACU can be viewed in greater detail by the ACU referrer. They have extra facilities such as the ability to add progress notes and request diagnostic services for the patient under that referral.

If a staff member from the ACU makes a new referral, they also need to initiate the shared care plan for the patient by filling in the “Shared Care Details” form. This form needs to be approved by the PHN since they are responsible for allocating nurses to referred patients. Once approved, the patient is ready to receive care from these nurses.

The referrer is also responsible for deciding when it is suitable for discharging the patient from the shared care plan. Once again the referrer needs to initiate the discharge details by filling out the discharge form. This discharge form needs to be approved by the PHN before the patient is officially discharged.

Referring General Practitioner

Referring GPs can also refer patients into HHIS the same way as the ACU. However GPs are not involved in approving the shared care form for referrals made by the ACU.

Primary Health Nurse (PHN)

Primary Health Nurses are concerned with organising the community aspect of care that patients receive. PHNs are responsible for checking the shared care plan made by referring GPs or the ACU and allocating nurses for the patient.

PHNs are required to perform a safety check of the patient’s home to ensure that the premises are satisfactory for the patient to be receiving care. If the patient is already under a referral, the PHN is still responsible for checking the safety

of the patient’s premises. However, since a safety check would have already been performed for a previous referral, the PHN will not have to fill in a new “Safety Check” form. Instead the details from the previous form will be available to the PHN. It is up to the PHN to ensure that the previously filled in details are correct, and if not, they need to edit the changes on the form.

The final duty of a PHN is to formulate a community care plan. These “Community Care Details” are an extension to the shared care details, and are related more specifically to the community aspect of the care.

Community Nurse

Once the patient’s shared care program is approved, the patient is able to start receiving care from community nurses who were pre-allocated by a PHN. Normally a patient is allocated to specific nurses, however other nurses are also allowed to administer care on a once-off basis. This is necessary if the allocated nurses are unable to visit the patient for a particular visit.

The main role of the community nurse is to administer the care needed by the patient. This can include the administration of medication, cleaning of wounds, exercise and many other aspects of care. The nurse will need to document the events of each visit. This is done on a “Community Care Visit” form, which the nurse must fill out for every visit. The form will summarize the care that was administered for the patient for a particular visit.

It is important to note that the care administered by these nurses will cover all referrals that the patient may be under. For example, if the patient is under different medications for different referrals, the nurse will be administering all of these to cover all referrals.

The nurse may also want to add progress notes or even request diagnostic services for the patient. These have to be made under each referral that the patient is under. For example, if the patient needs an x-ray for one of the referrals, the diagnostic request must be made under that particular referral.

Apart from these main tasks, a nurse may also edit the “Safety Check” or “Community Care Details” forms, which are normally first filled out by a PHN. The information originally filled out may often change and the nurses are therefore allowed to change these if required.

With all HHIS interactions, an audit trail is maintained so it is possible to review past changes to plans, medications and treatments. Another feature of HHIS is that users are required to acknowledge various aspects of care by completing an authorisation form and digitally ‘signing’ this form.

Database Schema

A graphical representation of the simplified HHIS schema is given in Fig. 1. The clients of HHIS are uniquely distinguished by the Client_ID. The Client table stores information that is mandatory for every client of HHIS. For

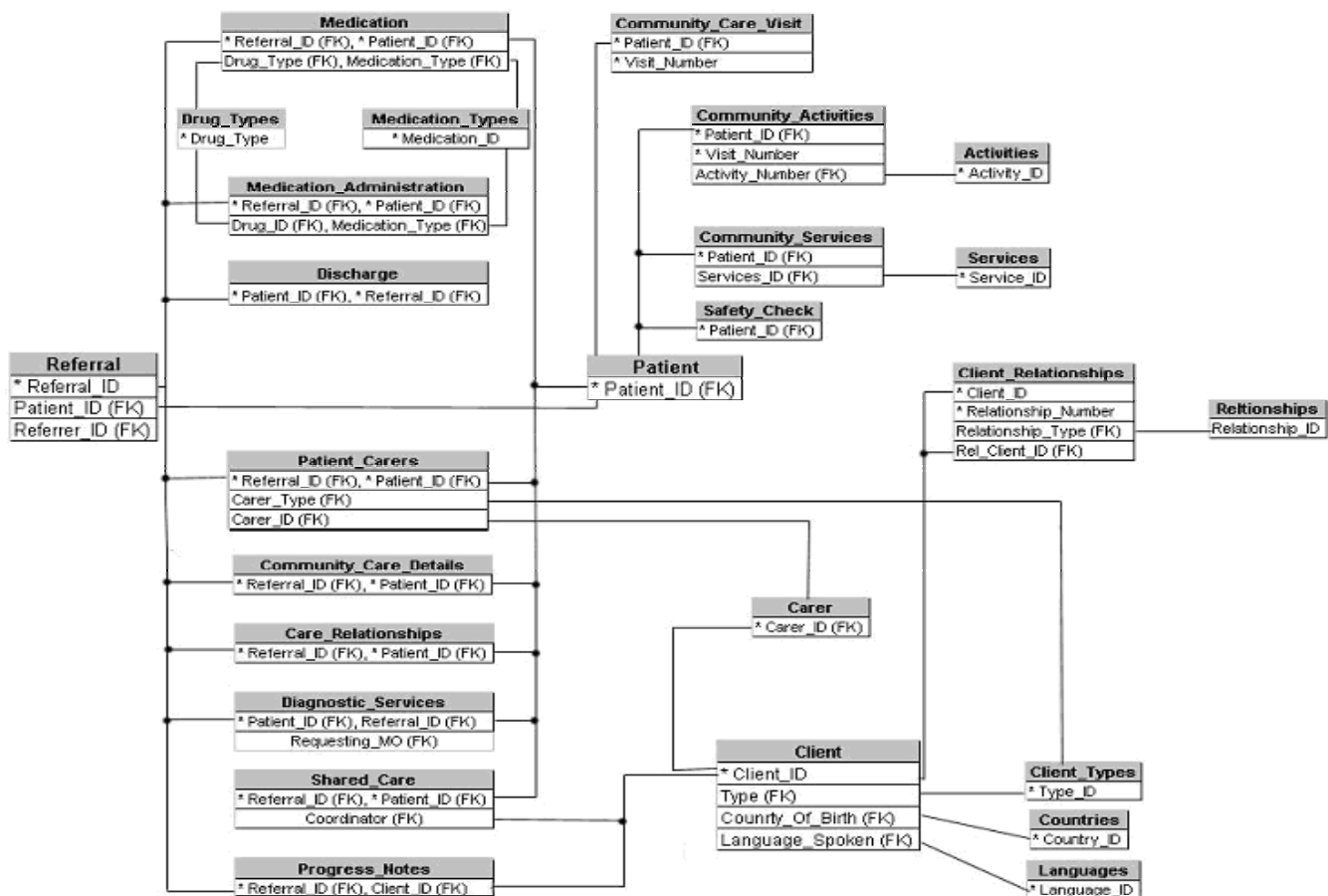


Fig. 1. Simplified database schema of HHIS showing the major primary and foreign key linkages.

example, every client has a first and last name and is either female or male.

Each client of HHIS inherits information from the Client table. For example, a patient of HHIS is a client. A patient's general information is stored in the Client table and specific 'patient' information is stored in a Patient table. Similarly, a doctor's general information is stored in the Client table and doctor specific information is stored in the Doctor table. The Client_ID unique identifier holds the relationship between the tables.

GPs refer patients. Upon referral, a unique identifier is created, the Referral_ID. All information specific to the referral is stored in the Referral table. Foreign keys Referrer_ID and Patient_ID link the referral to the patient and referring GP.

Once a patient is referred, a GP may request a diagnostic service for a patient. Information for this request is stored in the Diagnostic_Services table. Each patient may have many diagnostic service requests. The foreign key Referral_ID allows the request to be linked to the referral table.

Before a patient starts receiving care from the community nurses, an agreement of care is formulated between any parties involved. For example, the Primary Healthcare Nurse may need to allocate nurses and the GP may need to prescribe medications. This agreement of care could be

considered as a contract between the parties. Like a contract, all parties must agree on the care to be performed. There needs to be an agreement of care for each patient and for each referral.

Patients may also have safety checks, receive community care and have medication administered to them. A nurse at a patient's home does a safety check. This form may be altered at a later date if required. As this information may be changed at any time and stored once for every patient, we need only one unique identifier, the Patient_ID.

Patients receive community care from visiting nurses. Each patient may have many visits. There may be instances where a patient may be referred by different doctors for more than one problem. This is handled by the fact that any one visit may take care of all referrals.

Patients may also receive medication from nurses. Each patient may have different medications administered for different referrals. A medication type is a grouping of medications. For example a group may be "Nurse Initiated Medication". The Drug_ID is a foreign key to a table, which contains information about that medication. To record the time and details of administration, a sub table called "Medication_Administration" is used. This table shares all the keys of the parent table but contains the extra fields for the administration specific data.

III. IMPLEMENTATION

The technologies used to implement HHIS are Microsoft SQL Server 7.0, Microsoft Windows NT server, Cold Fusion, JavaScript and HTML. The design and construction of a database containing all relevant data required for this system is done using Microsoft SQL Server 7.0. To access the database, several web-based forms accessible to different users of the system are implemented using the Cold Fusion application suite. The web-based forms are used to interface with the SQL database as well as input data and generate reports from the database. Other tools and technologies used include basic HTML, DHTML and JavaScript for the presentation of the web-based forms. The web-based forms are designed to comply with a number of the latest web-browser standards, namely Microsoft Internet Explorer and Netscape Navigator.

Fig 2. gives an indication of the HHIS user interface showing one of the approximately one hundred forms implemented. A field trial of HHIS is currently underway within the South West Area Health service of Sydney. For home use, nurses have been equipped with notebook computers and GSM modem connections to dial-in directly to the HHIS web server.

IV. CONCLUSIONS AND FUTURE DEVELOPMENTS

The purpose of having a web-based system is to allow users of HHIS to access facilities and tools via the Internet. The fact that the system is accessible over the Internet is beneficial to the end users as this medium is readily accessible from almost anywhere in the world and provides a solution for community nurses who need to visit patients at

their home. The system also benefits from being web-based because no HHIS software is required to be installed on the user's computer apart from a standard web browser. From initial results of the field trial, HHIS appears to be fully functional and an effective means of managing ambulatory care patients. Naturally a thorough evaluation of the field trial will contribute greatly to our knowledge of the efficacy of the system.

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