The Patient Data Analysis Information System: Addressing Data and Information Quality Issues

David Sammon[1], Kieran A. O'Connor[2] and John Leo[1]
[1]Business Information Systems, University College Cork, Ireland
[2]Mercy University Hospital & South Infirmary Victoria University Hospital, Cork, Ireland
dsammon@afis.ucc.ie

Abstract: This paper reports on the development and initial end-user evaluation (after ten months in-use) of a Patient Data Analysis Information System (PDA-IS) for Geriatric Medicine. The development and evaluation is the first phase of a larger ongoing research project. The PDA-IS contains a set of high integrity patient data records (a local practice-based repository of clinical patient data) available for the Consultant Physician in Geriatric Medicine. The evaluation of the system identifies the wide range of benefits that were realised by the Consultant Physician and indeed could be expected in the future from the deployment and extension of such a flexible solution for all Consultant Physicians in hospital practice that need to collect patient data.

Keywords: geriatric medicine, patient-centric data, data integrity, relational data model, n-tier architecture, evaluation.

1. Introduction

In the editorial of the *Medical Informatics and the Internet in Medicine* journal in March 2007, the editor called for the need for more research illustrating the application of Information Systems/Technologies in specific clinical areas (Bryant, 2007). In this paper, we report on the development of a local practice-based repository of clinical patient data, as part of a larger ongoing research project. The Patient Data Analysis Information System (PDA-IS) provides functionality to a Consultant Physician in Geriatric Medicine in terms of storing and analysing high quality clinical patient data for the purposes of more informed and accurate decision making. The system's general aim is to support the Consultant Physician in improving the quality of healthcare delivery. Indeed, the most important objective of medical documentation in general is to contribute to the effective and appropriate medical care of each individual patient. This project involved several rounds of interviews between the academic development team and the end-user of the Information System (Consultant Physician) towards the specification of a suitable normalised data model and a User Interface (UI) to support an integrated approach to data capture and analysis. Following the development of the prototype, the system was in-use for over ten months after which time more interviews took place between the developers and the end-user to establish the range of benefits obtained from the application in-use and the need for extensions and further development. This paper reports on the prototype developed, its core features in support of the Consultant Physician's needs and the initial benefits from the PDA-IS in-use.

The paper is organised as follows. The next section presents an insight into the need for Information Management in healthcare. This is followed by a presentation of the critical contextual elements of the case that describe the context in which the decisions are made by the Consultant Physician in this study. Based on this scenario, we then explore how data quality can be ensured and describe the multi-tiered application we developed to meet the needs of our end-user. Finally, we present feedback on the use of the PDA-IS and explain the benefits that the application delivered to the end-user and additional developments that are planned for the future as a result of the Consultant Physician's feedback.

2. Patient information management

With rising costs and increasingly stretched resources, it is no surprise that the healthcare sector has become focused on strategies to improve the quality and efficiency of health services. Health care experts, policymakers, and consumers consider Health Information Technologies (HIT) to be critical to transforming the healthcare sector (Institute of Medicine, 2000; 2001; FACCT, 2003; Asch *et al*., 2004; Department of Health and Human Services, 2004; Epstein *et al*., 2004; Smith, 2004). However, while the benefits of Information Systems/Technology may be clear in theory, introducing new systems/technology to healthcare has proven difficult and rates of use are limited (Ash *et al*., 2003; Ash *et al*., 2004; Valdes *et al*., 2004). Central to these strategies to improve the quality and efficiency of health services is the implementation and the development of innovative systems, such as Health Information Systems (HIS), which support the collection, distribution and analysis of patient data. Indeed, while data quality is increasingly important to organisations across a variety of sectors, it is especially true in healthcare where cost pressures and the desire to improve patient care drive efforts to integrate and clean organisational data (Leitheiser, 2001).

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Assessing data/information quality is not an exact science although various aspects of quality and information have been investigated to date (cf. Kahn *et al*., 2002; Ballou *et al*., 1998; Kovac, *et al*., 1997; Strong *et al*., 1997; Pitt *et al*., 1995; Reeves and Bednar, 1994; Zeithaml *et al*., 1990). In fact, Wallis *et al*. (2007) argue that assessment criteria for data integrity and data quality will vary considerably by type of data and by scientific domain. However, decision-makers depend on quality data/information for effective operations and decision-making (Price and Shanks, 2004).

Using Information Technologies, but embracing a localised perspective, provides various degrees of intelligence towards generating diagnosis based on locally maintained patient data. However, as well as healthcare data being important to the individual patient, appropriate collection and analysis of multiple individual datasets can inform healthcare practice and promote the health of the local geographical population (Institute of Medicine, 2000; 2001; FACCT, 2003; Asch *et al*., 2004; Department of Health and Human Services, 2004; Epstein *et al*., 2004; Smith, 2004). Indeed, developing such systems raises a variety of issues, such as data modelling issues to begin with, as pointed out by Silverston (2001). He argued that healthcare entities need to track information about actors involved in healthcare, specifically patients, and presented a number of data models relating to the way that the specific types of data that need to be captured and tracked should be organised. From our perspective we argue that patient information on 'medical conditions and physical characteristics', 'health care visits, delivery, episodes, symptoms and incidents', and 'diagnosis and delivery outcome' is not readily available to the medical practitioner community at the local level and this opens the door to IS practitioners to address this issue and facilitate computerised data capture and analysis (information provision) in support of building a local practice-based repository of clinical patient data.

Szirbik *et al*. (2006) suggested that to better understand the resource use and population needs for health and social care services for the elderly, thorough Information Management (IM) is needed. In fact, as the world population is ageing (O'Connor *et al*., 2008; Gannon et al., 2007; Xie *et al*., 2006) the need for this greater understanding is immense, especially in the Republic of Ireland where the ageing population is set to place yet another burden on an already struggling health service. People aged 65 and over in the Republic of Ireland currently account for approximately 11% of the total population and this proportion is expected to increase over the next twenty years due to an increase in life expectancy; for example, it is expected that by 2031, there will be 1.04 million people aged 65 and above in the Republic of Ireland (Gannon et al., 2007). As commented by Sim *et al*. (2001, p.530) *"systems that provide both patients and clinicians with valid, applicable, and useful information may result in care decisions that are more concordant with current recommendations, are better tailored to individual patients, and ultimately are associated with improved clinical outcomes"*. To achieve Information Management there is a need to define a standard set of data and analysis techniques have to be developed and implemented. This problem of non-standardised data definitions has impacted on all types of organisations for several years and unfortunately still does today (see for example the emergence of the recent concept of Master Data Management). Interestingly enough almost twenty years ago Goodhue *et al*. (1988, p.373) reported that *"a major bank seeking to shift its strategy toward a focus on customers finds that it cannot determine how profitable individual customers are, or even what its total business is with each customer, because its customer codes are not common across branches or lines of business"*. Indeed, as can be observed in the context of our research project, a degree of separation needs to exist between the physical hospital locations and the required data definitions needed for the effective delivery of patient-focused health services. Indeed, Szirbik *et al*. (2006) further comment that irrespective of large scale nationwide IM projects, smaller academic projects (similar to our approach) should help establish models for data analysis and provide tools for practitioners related to the area (Geriatric Medicine in this case). Therefore, similar to Szirbik *et al*. (2006) we classify our PDA-IS as a repository for improved decision making in elderly healthcare.

3. Understanding the context of the problem

The Consultant Physician in Geriatric Medicine works across two hospital sites in Cork city in the Republic of Ireland. The Consultant Physician collects patient data from the following service areas: acute in-patients, out-patients, a Medical Rehabilitation Unit (MRU), and consultations. The structure of the overall service is illustrated in Figure 1. *Hospital A* and *Hospital B* operate as two separate independent entities; however, the Consultant Physician provides an integrated service across both entities. The service offered by the Consultant Physician is available to approximately 36,000 people aged over 65 years living in the Cork north Lee and south Lee health service areas.

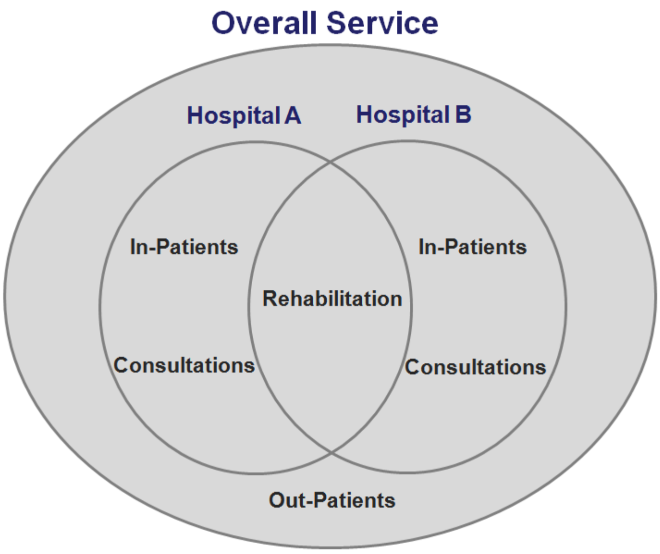

Figure 1: Operational environment

The independence of both hospitals creates its own problem for the Consultant Physician in that both hospitals use different Hospital Information Systems (HIS) for managing patient records; therefore, different data definitions are used to define a patient in *Hospital A* and *Hospital B*. In simple terms, a different patient record number (*ChartID*) is used in each hospital to identify the same patient. The practicality of this problem for the Consultant Physician is that patient mobility between the two hospitals is a common occurrence, and outside the boundaries of each individual hospital, it is extremely time consuming and inefficient to get an overall profile of a patient within the service. Unfortunately, for a number of years the Consultant Physician collected his patient data and logged his clinical observations in self-designed Microsoft Excel spreadsheets. This translated into the existence of at least five (heterogeneous) spreadsheets being maintained on an on-going basis for the service areas, which reflected a fragmented approach to data capture and resulted in the existence of information silos. However, taking on board the issue of different patient record numbers existing in both hospitals; this led to a data collection that was primarily hospital-centric as opposed to patient-centric, which mirrored the inefficiency inherent in the patient data definitions of the two Hospital Information Systems, and this further curtailed the ability of the Consultant Physician to view a patient's history across the service areas.

In the IS area, practitioners are well aware of the observation that an Information System is only ever as good as the store of data. However, it is also the fact that the use of incorrect data structures for storing data can significantly hamper its retrieval and analysis. The lack of a normalised data structure for instance can lead to data inconsistencies and redundancies that prevent associations and patterns in the data being identified during analysis. Indeed, in the context of our project despite the non-value-added nature of generating a patient history from the collection of Excel spreadsheets, there was also the issue of data integrity and the Consultant Physician's low level of trust in the accuracy of the information. Overall, the Consultant Physician's patient data was not defined in a uniform and standardised way and this poor categorisation of data resulted in the cumbersome production of low-value information. For example, where a patient was readmitted to hospital, the Consultant Physician collected his clinical observation data on the patient, however, this translated into a row being added to the Excel spreadsheet (a new record was created) illustrating that patient data was unnecessarily duplicated in these circumstances.

As a result of the inadequacies of the patient data and the process followed in analysing this data, the purposefulness and usefulness that the data could have possessed was diminished to the extent that the Consultant Physician had doubt about the data's reliability and trustworthiness. Furthermore, the Consultant Physician had limited querying tools available to him where he was limited to the use of filters in Excel. However, these Excel features were simply used to analyse the data, to abstract various facts of importance, and these results were used for personal clinical observations, as well as supplementing reports that the Consultant Physician produced. Therefore, the development of a localised custom-built Information System (PDA-IS) that would provide flexibility in design to facilitate the operations of this Consultant Physician in his collection, management, and analysis of patient data in Geriatric Medicine was undertaken.

3.1 Approach to developing the proposed PDA-IS solution

The PDA-IS was developed over a six month period from October 2006 – March 2007 and the prototype application has been in use since April 2007. In the first two month period of the project several rounds of interviews took place between the academic development team and the Consultant Physician, in an effort to establish the core user requirements. These user requirements were translated into a series of activity models and logical data model designs by the academic development team, which were then used as communication tools to agree the Information System's features with the Consultant Physician, in addressing the user's requirements. As a result, the activity models and logical data model designs were continually refined during each round of interviews until a complete set of models existed, embracing both stakeholder groups' understanding of the problem area, to guide the development process. Therefore, the remaining three months of the project timeframe was focused on the database and prototype software development activities. This three month development period would be best described as following an iterative prototyping approach in that when additional functional features were added to the PDA-IS the Consultant Physician was called upon to provide feedback following guided usability testing.

4. Functional and technical architecture of the patient data analysis information system

The technical deign of the application followed an n-tiered architecture (a five layer model in this instance) as illustrated in Figure 2. This five-tiered application architecture is state-of-the-art, although not always embraced in approaches to application development (see for example Microsoft: http://www.microsoft.com/belux/msdn/nl/community/columns/hyatt/ntier1.mspx). The rationale for such a design was motivated by the desire to allow for greater flexibility and scalability, as well as the maintainability and manageability of the application for the future. For example, each layer of the application was developed independently, adhering as much as possible to standards facilitating communication with the layers above and/or below. The application was developed in the Microsoft Visual Studio® 2005 Integrated Development Environment (IDE), facilitating the use of the .NET Framework 2.0. The .NET Framework is free to download and supports object-oriented programming, facilitating component development that can operate across a broad range of computing devices, including mobile devices (for example a pocket PC).

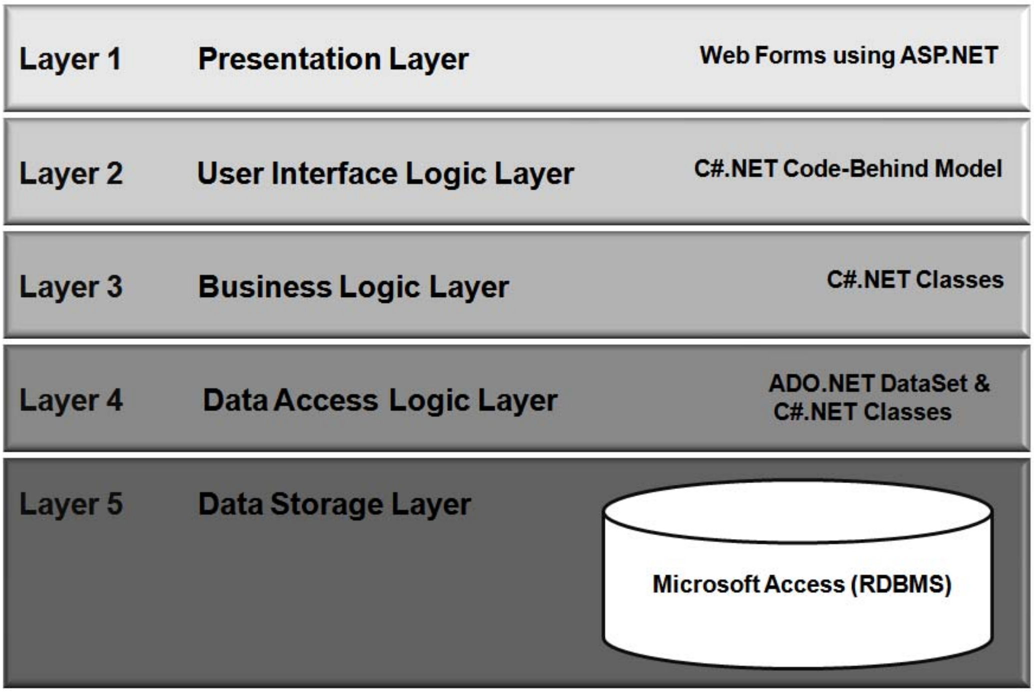

Figure 2: Five-Tiered Architecture of the PDA-IS

A more detailed explanation of each layer of the PDA-IS is provided as follows:

- Data storage layer

A highly complex and sophisticated relational data model, implemented in the Microsoft Access Relational Database Management Systems (RBDMS) is at the core of the application. The data model dictates the way in which the data is logically structured and stored for retrieval. As previously discussed, the design of the data model was agreed following a number of requirements meetings with the Consultant Physician. As an example some of the patient-centric data dimensions that needed to be captured by the PDA-IS are illustrated in Table 1. Furthermore, several component parts of this comprehensive relational data model are discussed in section 4.1.

- Data Access Logic Layer

The Data Access Logic Layer is a reusable interface to the data source (Microsoft Access in this instance) which is also known as abstraction. Its existence facilitates an easier transition to an alternative data source (for example: Microsoft SQL Server, Oracle, MySQL, etc.).

- Business Logic Layer

This is the *'brain'* of the application and provides increased control over the operations of the application. This layer contains business rules, constraints, data manipulations, etc.

- User Interface Logic

This layer acts as a control for the Presentation Layer, for example it controls making ASP.NET components visible or invisible, enabled or disenabled, etc. Ultimately, this layer provides a specific logic to the particular *.aspx* Web Form.

- Presentation Layer

This layer provides a User Interface (UI) for the application. This layer works with the code-behind model (User Interface Logic) to handle the transformation of end-user input as well as application output. The *themes/skins* functionality of Visual Studio® 2005 was also used in order to create templates for all Web Forms and controls (User Interface components). Furthermore, Cascading Style Sheets (CSS) were used to control the style and layout of the User Interface. Therefore, the look and feel of various controls could be defined from one central source, so as to ensure consistency across the Presentation Layer.

Table 1: Patient-Centric data dimensions

Dimension	Description
Length of Stay	[Date Admitted] – [Discharge Date]
Discharge Destination	Home, Back to Nursing Home, Long Term Care (LTC), Hospital Transfer, Transfer to Team, Rehabilitation Unit, RIP, etc.
Home Situation	Lives Alone, Sheltered Accommodation, Hostel, Lives w/Spouse, Lives w/Siblings, Lives w/Brother or Sister, Lives w/Carer, Lives w/Other, Other, etc.
Mobility	Unaided, with Stick, with ZF, Bed-Chair, Bed-Bound, Other, etc.
Measure of Function	Tests are conducted and scores recorded on Admission & Discharge for the Barthel Index (BI). The change in the BI value is also recorded.
Measure of Cognition	Tests are conducted and scores recorded on Admission & Discharge for the Abbreviated Mental Test (AMT). The change in the AMT value is also recorded.
Reason for Referral	Rehab, Stroke, Respite, LTC, Medical Advice, Other, etc.
Department	Cardiology, Respiratory, Neurology, Clinical Pharmacology, Rheumatology, General Surgery, Gastroenterology, etc.

4.1 Managing high quality Patient-Centric data

There is often much debate about the value and methods of designing a normalised logical data model during the analysis phase of an IS development project. The obvious benefit of designing a logical data model is that it describes the functional, as well as data, requirements within the scope of the project's problem domain. In the context of this research project it was obvious at the outset of the project that data was captured and stored using a hospital-centric as opposed to patient-centric perspective and there was no formal categorisation of master data elements existing in the Consultant Physician's Excel spreadsheets solution which led to the cumbersome production of low-value information. In an effort to provide the Consultant Physician with a patient-centric means of data collection and visibility of a patient's history across the service areas a comprehensive logical data model design was agreed for the PDA-IS. To focus on the key aspects of the PDA-IS in this paper, we are only explaining a subsection of the data model for the purposes of readability and clarity. These key aspects of the PDA-IS (namely: *patient-centric admissions* and *diagnosis and sub-diagnosis categorisation*) are discussed in sections 4.1.1 and 4.1.2 respectively.

4.1.1 Patient-Centric admissions

Figure 3 illustrates a portion of the overall data model that was designed for the PDA-IS and embraces a patient-centric admissions process for the service areas. By its design the data model allows for the realities that older patients may be admitted more than once across the various service areas and may be issued with more than one patient record number (*ChartID*), depending on the physical hospital location for each of these admissions.

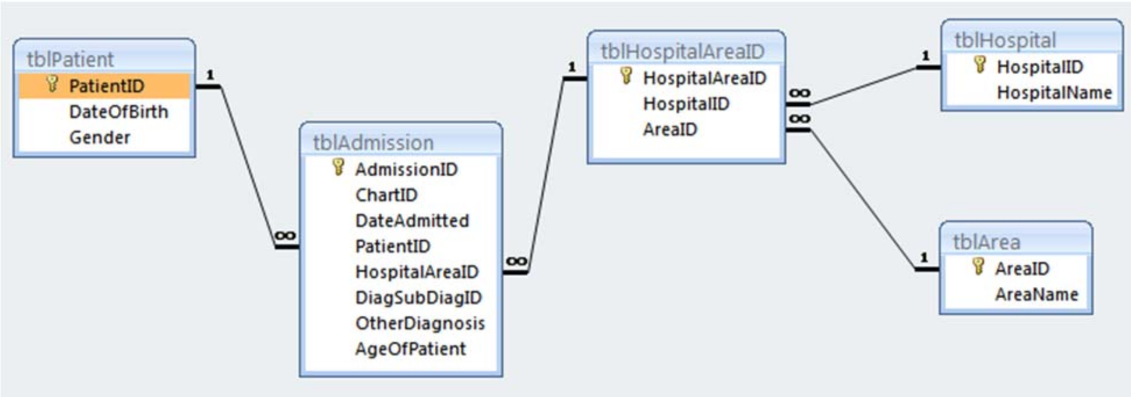

Figure 3: Patient-Centric Admissions for the Service Areas

To achieve this flexibility and meet a key requirement of the end-user, each patient is assigned a unique *PatientID* which is referenced each time a patient is readmitted throughout the various locations of the service areas. While the *ChartID* (a number generated by the hospital administration) is also captured for each patient's admission it is not the primary identifier of each patient in the PDA-IS data structure. Also, with the operation of the service areas split across two hospitals (as illustrated in Figure 1), this reality is captured by defining a master data category of *Hospitals* and *Areas*, thereby creating a combination of service areas to hospitals, as captured in the *tblHospitalAreaID* table. Therefore, each admission is classified against a *HospitalAreaID*; as an example, if an older person has been admitted to in-patients in the MUH, *HospitalAreaID* 2 is used; however, this patient may be seen again (readmitted) in out-patients at the SIVUH and would be categorised using *HospitalAreaID* 5. This *HospitalAreaID* relationship structure is illustrated in Figure 4 using a sample set of data records.

tblHospitalAreaID		
HospitalAreaID	**HospitalID**	**AreaID**
1	2	1
2	1	2
3	3	4
4	2	2
5	2	3

tblHospital	
HospitalID	**HospitalName**
1	MUH
2	SIVUH
3	-
4	Other

tblArea	
AreaID	**AreaName**
1	MRU
2	In-Patients
3	Out-Patients
4	Consultations

Figure 4: Logical Representation of Service Areas across both Hospitals

4.1.2 Diagnosis and Sub-Diagnosis categorisation

Each patient admission has an associated *Diagnosis* with *SubDiagnosis* categorisation. This provides a detailed and thorough categorisation of the older person's diagnosis and sub-diagnosis for each admission to the service areas. Figure 5 illustrates a portion of the overall data model that was designed for the PDA-IS and embraces a *Diagnosis* with *SubDiagnosis* categorisation for each patient admission to one of the service areas.

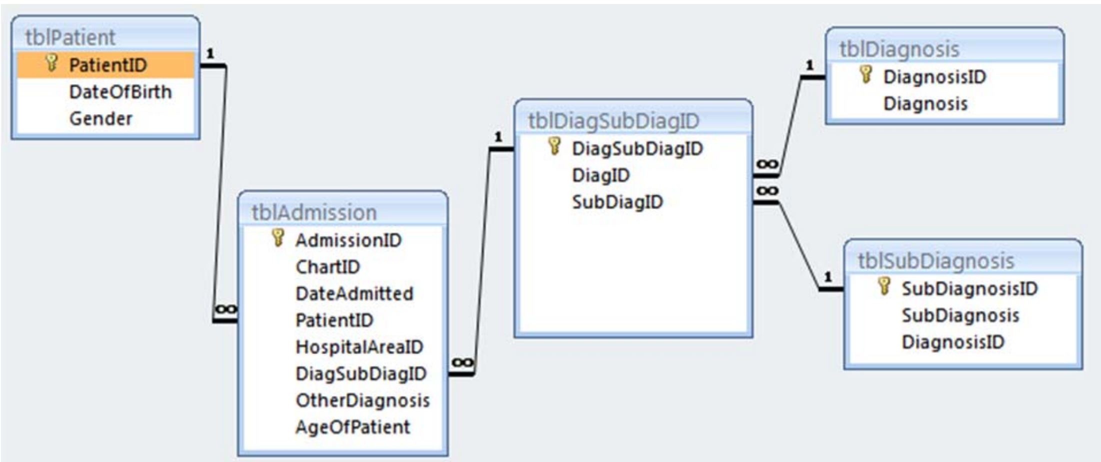

Figure 5: Diagnosis & Sub-Diagnosis Categorisation for each Patient Admission to the Service Areas

This *Diagnosis* and *SubDiagnosis* master data categorisation provides the Consultant Physician with thorough and insightful data to build an accurate patient case history across the service areas, and also provide an insight into the profile of patients across the service areas by types of *Diagnosis* and *SubDiagnosis* captured for each admission. Figure 6 illustrates this *Diagnosis/Sub-Diagnosis* relationship structure using a sample set of data records.

tblDiagnosis	
DiagnosisID	**Diagnosis**
3	Secondary Neoplasm
4	Benign Neoplasm
5	Anaemia
6	Hypothyroidism
7	Hyperthyroidism
8	Diabetes Mellitus
9	Malnutrition
10	Obesity
11	Dementia

tblSubDiagnosis		
SubDiagnosisID	**SubDiagnosis**	**DiagnosisID**
16	Bone Metastases	3
17	Lung Metastases	3
18	Liver Metastases	3
19	Pleural Metastases	3
21	Nutritional	5
22	Iron Deficiency	5
23	B12 Deficiency	5
24	Chronice Disease	5
27	Type I	8
28	Type 2	8
31	Alzheimer's Disease	11
32	Vascular	11
33	Mixed	11
34	Lewy Body	11

Figure 6: Example of Diagnosis & Sub-Diagnosis Master Data Categorisation

As an example, it can be observed from Figure 6 that *DiagnosisID* 11 (Dementia) has four possible sub-diagnosis that each older patient can be classified against, namely *SubDiagnosisID* 31, 32, 33, 34 respectively. Also, the Consultant Physician can continually add master data elements in the form of diagnosis categories and associated sub-diagnosis categories, using the administrative UI of the PDA-IS, as illustrated in Figure 7.

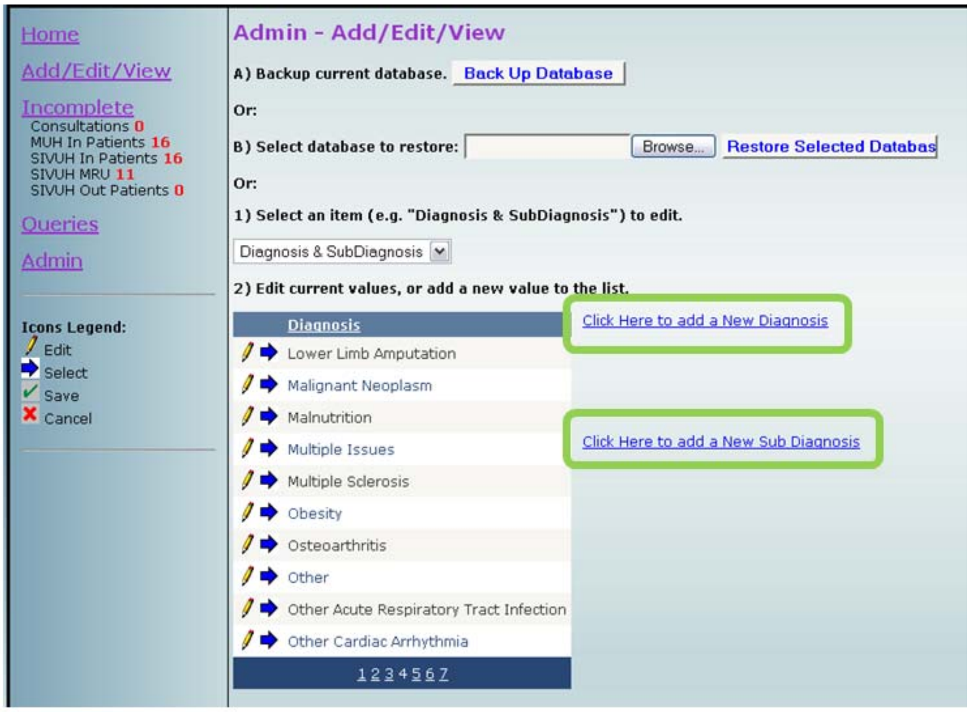

Figure 7: PDA-IS Administration User Interface (UI)

5. Benefits of the Patient Data Analysis information system

Identifying benefits can be considered a good communication tool and checklist for consensus-building in discussions on the role of IS in organisational contexts (in this case Geriatric Medicine). However, assessing the level of benefit realisation from the use of an Information System is a somewhat subjective exercise and should be considered from the perspective of the end-user and their view on the value of the application in support of their activities. To put some formalised structure on the benefits discussed in this section we use the dimensions of the SOLE quality model discussed by Ozkan (2006) with regard to assessing IS quality. This high level assessment of the PDA-IS is presented in Table 2.

Table 2: PDA-IS Assessment across the Dimensions of the SOLE Quality Model (after: Ozkan, 2006)

IS Quality Dimension	Description	The PDA-IS Case
Business Quality	If benefits offset costs, then IS quality is considered to be good	In monetary terms the PDA-IS was developed at zero cost. Although academics and a medical practitioner's time was involved, a rich collaborative culture has now been created, facilitated by the delivery the PDA-IS prototype
Use Quality	Defined by how well the IS does what the end-user wants it to do (focusing on requirement quality and interface quality)	Facilitates the collection and storage of patient-centric data of high integrity Facilitates the generation of standard and ad-hoc analytical patient- and service-centric queries using the query engine; therefore; delivering high quality patient- and service-centric information in a timely fashion
IS Work Quality	Considers the management tasks required to guarantee 'fruition and evolution quality' and 'user support quality' concerning all aspects of the way the IS serves the user	While the PDA-IS has been in use for over ten months, no performance issues have been reported and all maintenance and operations associated with the PDA-IS have been managed by the Consultant Physician

At the outset of the PDA-IS project it was clear what system functionalities were needed to support the Consultant Physician but it was somewhat uncertain as to the benefits that would be realised from the system in-use, and how these benefits would be measured. However, unlike Doherty *et al*. (2008) while we didn't strive, explicitly at the outset, to make benefits the focal point of our development project, it became apparent following the initial period of the system in-use that several benefits had materialised and were realised by the key stakeholder. Therefore, based on an analysis of the subjective views of the Consultant Physician in Geriatric Medicine, the PDA-IS was deemed to provide the following functional benefits:

- facilitates the collection and storage of patient data:
  - highlight patients that have incomplete data – this is facilitated through using the simplistic snapshot view of incomplete patient records on the application's menu bar (see Figure 8)
- facilitates the generation of numerous standard and ad-hoc analytical queries on the patient data to:
  - establish the profiles of patients based on their experience across the healthcare service areas
    - track the average length of stay of patients
    - track discharge destinations
    - track changes in BI & AMT (see Table 1) – these simple measures of function and cognition respectively are not collected in any other computerised system in Hospital A or Hospital B. In fact, these are the measures that highlight the complexity of a patient and they determine the dependence of a patient, for example influencing their length-of-stay in hospital, or indeed their mortality. Surprisingly, no provision is made in either hospital to collect and store these measures.
  - discover 'path patterns' or 'pathways' of patients in the healthcare service area
    - analyse patients with stroke, establish how long on average they are in hospital and if there is a difference between patients with different types of stroke
  - identify possibilities for improvement in healthcare provision
    - track the number of patients in different service areas
    - track length of time patients wait for MRU admissions
    - provide local patient analysis for Syncope Studies, Stroke Unit and Falls Clinic developments

Indeed, the power of the query engine developed at the core of the PDA-IS was deemed as one of the most valuable aspects of the application by the Geriatric Physician, specifically because of the flexibility it offered in conducting data analysis. The design of the query engine allows the end-user to choose a pre-built 'basic' SQL statement and modify it with unlimited criteria (extending the *where* clause of the SQL statement) from the User Interface as illustrated in Figure 8. Therefore, the complexity and sophistication of the query engine design is represented to the end-user in a visually sophisticated and logically ordered easy-to-use interface.

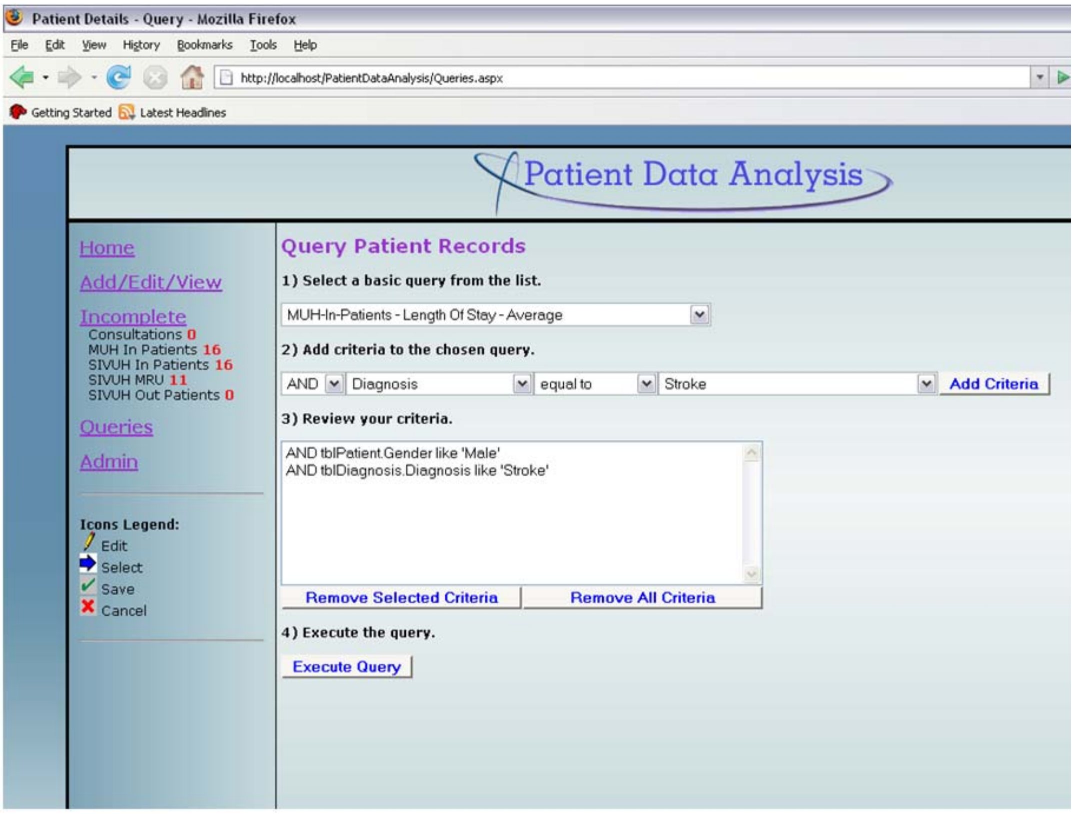

Figure 8: PDA-IS End-Users Query Engine User Interface (UI)

The querying process works as follows:

- Client chooses a basic query (SQL statement);
- Client chooses data parameters to query against e.g. gender, hospital, diagnosis, etc;
- Client specifies the criteria for that data e.g. equal to male, Mercy Hospital, Amnesia, etc.;
- Client executes the query:
  - A Query class takes the basic SQL statement and dynamically adds in the *where* parameters and criteria.
  - A Database Connection class executes the SQL statement against the database.

When the Consultant Physician chooses 'Execute Query' on the UI, the returned dataset is outputted to an Excel spreadsheet for immediate viewing and, if required, graphical representation. An example of such an output is illustrated in Figure 9. The rationale for using Excel is one of familiarity and the inherent ease-of-use of the application for the Consultant Physician.

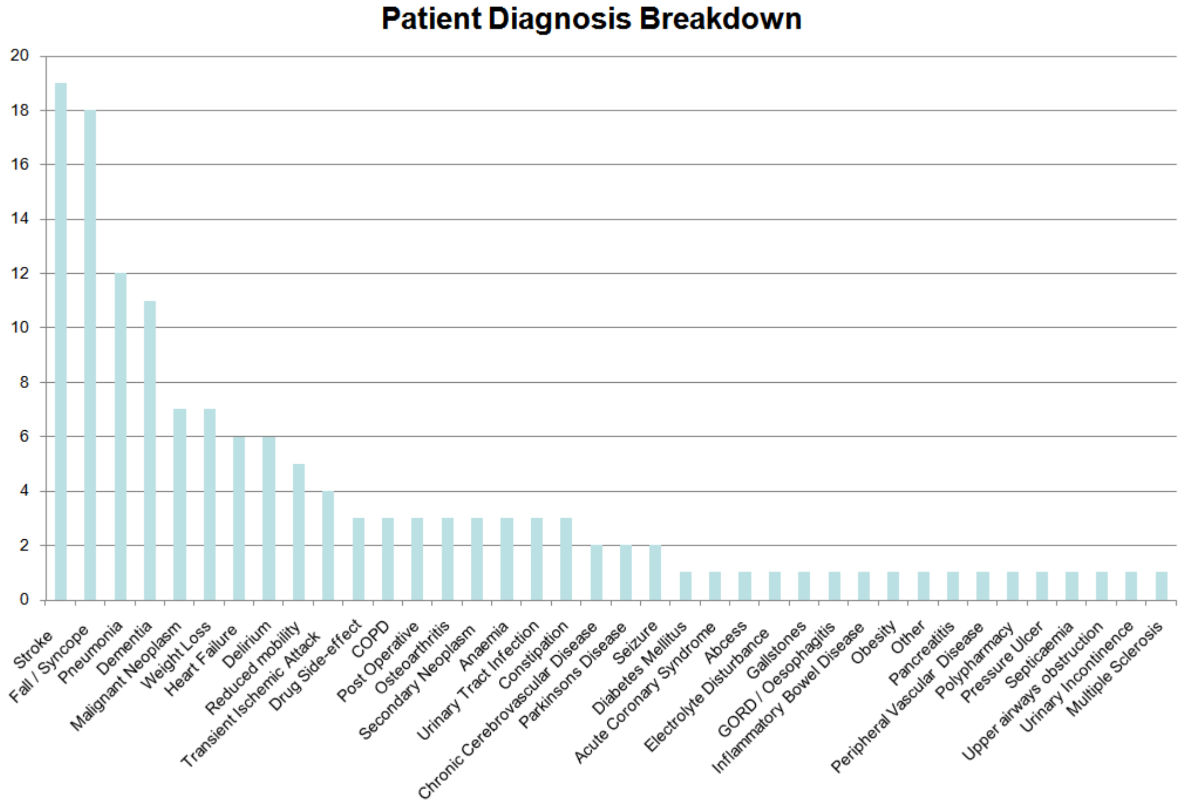

Figure 9: Patient Diagnosis Breakdown Charted in Excel

Overall, the Consultant Physician's feedback confirmed that the PDA-IS provides a number of easy-to-use User Interfaces (UI) facilitating accurate patient data entry and with the existence of the relational data model at the core of the application also has a standardised set of data definitions. Furthermore, the query engine and the flexibility it provides to analyse the data facilitates the representation of the complexity of each individual patient and indeed the local patient population which is the ultimate in terms of the provision of better healthcare at the local level.

6. Concluding remarks

To conclude we embrace the views of Kunene and Weistroffer (2006, p.984) when they suggest that "the vast and growing collection of healthcare data and the willingness of clinicians to explore different technologies and methodologies to analyse this enormous amount of data has recently opened up new analytical possibilities for clinicians, operations researchers as well as information systems researchers". Indeed, this willingness of medical practitioners to welcome new tools and techniques into their practices should be embraced by the IS academic community where both knowledge domains could be combined to produce patient focused solutions. By its design our PDA-IS can be easily extended to run on a national scale (e.g. throughout the Republic of Ireland) and cover the needs of all Consultant Physicians in Geriatric Medicine.

We believe that our approach to developing the PDA-IS is a step toward developing an informatics infrastructure to collect local practice-based evidence. This repository of local patient information can compliment the available scientific evidence (literature-based evidence). In addition, our modest academic project and the resultant system developed can be further extended through the formation of a practice-based research information network; however, we also appreciate at this current time that the PDA-IS in an individual solution to an individual problem. In addition, it must be stressed that this academic project was not funded by any agency, nor was it influenced by commercial stakeholders; in essence this development project was simply about meeting the needs of a Consultant Physician in Geriatric Medicine, who as a highly skilled professional was not benefiting from the efficient use and support of an Information System equipped to handle patient data analysis. Indeed, at the time of writing this paper, the Consultant Physician has continued to use the PDA-IS eight to ten hours a week on average, since April 2007; furthermore, the system contains almost 900 patient records (2007 & 2008) covering approximately 1,400 patient admissions. This is a true testament to the fact that the PDA-IS is a simple but effective tool developed to solve the Consultant Physician's problem regarding clinical patient data capture and analysis. It is also worth mentioning that the

Consultant Physician in Geriatric Medicine does not have to use this PDA-IS, it is a choice that he makes in support of his daily clinical activities. This project further illustrates the point that small localised projects of the nature of the PDA-IS (a local practice-based repository of clinical patient data) can have an impact in the medical area and can avoid the problem of trying to meet all 'larger nationwide' requirements from the outset, incorporating 'nice-to-haves' as well as 'must-haves', which can sometimes lead to an approach that seeks to ***'boil the ocean'*** in terms of what is being delivered, but ultimately ends up delivering very little!

Finally, upon near completion of the development of the PDA-IS it was revealed that several Consultant Physicians in Geriatric Medicine at the two hospital sites were faced with the same limitations with regard to the collection and analysis of their clinical patient data. This realisation is now further informing the next phase of our ongoing research project, the local impact of which is expected to be extremely positive in terms of introducing a larger group of Consultant Physicians to [1] an appropriate system to record patient data; and [2] a flexible analysis component; to provide the necessary information for the accurate and ongoing treatment of older patients. As a result of the successful completion of this phase of the PDA-IS project a vibrant research partnership has evolved and the development of PDA-IS (version 2) has commenced in October 2008, embracing a Co-Research approach to the development project (cf. Hartley and Benington, 2000).

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