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**Impact-ED: A new model of digital library impact
evaluation**

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Submitted in partial fulfilment for the award of PhD

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Declaration

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Abstract

Digital library development is a relatively new area of research and previously focus has been mostly on developmental issues or usability. However more recently the focus has started to shift towards impact evaluation both in the digital library and traditional library domains. But what do we mean by impact and how can we measure it? Does information retrieved from a library help to confirm existing user knowledge/decisions, provide new knowledge for the user to make a decision/action, or contradict the user's existing knowledge to prevent a wrong decision or action? Or does the information have no impact on user knowledge, attitudes and behaviour? This thesis identifies a need for a digital library impact evaluation model that allows for evaluation of real digital libraries in real world settings and of real use by real users. It suggests that development of an impact score for comparing library impact over time or between libraries is a feature missing in previous evaluations. It then develops a model and framework to meet this need and shows how the model can be applied on an actual library by using the National Resource for Infection Control (NRIC) as a case study. The model uses a combination of pre and post visit questionnaires, study beginning and end questionnaires, web server log analysis and interviews. The subsequent data analysis leads to the development of the impact score to show the NRIC's overall impact score to be 0.58 (maximum possible score of 1). The model was then refined following discussion of how it met the requirements for digital library impact evaluation. The thesis ends with a discussion of how the project has added value to the digital library research domain and with suggestions for future research to develop the model and its application further.

Chapter 1 – Introduction

1.1 Research context

Digital library development is a relatively new area of research and previously focus has been mostly on developmental issues or usability (Chowdhury et al 2006; Chowdhury & Chowdhury 2003). Digital libraries themselves are not consistently defined entities (Borgman 2003) and therefore evaluation has taken a back seat whilst developmental research has driven the field. But the field is now much more established with the term “digital library” widely used and a simple Google search for this phrase returns a mind boggling 106 million results! More specifically a basic keyword search for “digital library” in the ACM Digital Library shows the growth in digital library publications over time as follows:

- Between 1952 and 2000 only 4037 publications were published
- Between 2001 and 2004 this had risen to an additional 6979
- But between 2005 and 2008 this figure was now 14130!

With more research being undertaken the focus in digital library evaluation has started to shift towards impact evaluation (Chowdhury et al 2006) and this development has been mirrored in traditional library (McNicol 2004; Urquhart 2005) domains.

But what do we mean by impact and how can we measure it? Previous research in the 1980s and early 1990s has shown that traditional hospital library services can contribute to patient care and clinical decision-making (King 1987; Marshall 1992; O'Connor 2002). However these studies were often driven by the need for the library to assert its value in times of economic constraint, therefore the focus tended to be on efficiency of services, satisfaction with the library and its impact on decision-making through self-reporting by clinicians', rather than measuring any actual outcomes e.g. knowledge and attitudes, length of hospital stay, prescribing rates or patient satisfaction. In contrast, one study did focus on the impact of performing Medline searches on actual outcomes to show that searches performed earlier in the patient's hospital stay were associated with lower costs, charges and length of stay than those whose searches were performed later (Klein et al. 1994). But these are large scale resource intensive studies not always within the scope of digital libraries budgets and staffing levels.

There is potential for using an alternative approach of evaluating knowledge, attitude and behavioural changes in order to measure the impact of a library on its users (Madle et al. 2004). Social psychology suggests links between attitudes and behaviour (Ajzen 2006, Franzoi 2003) and this research applies this to healthcare digital library evaluation. Does information retrieved from a library help to confirm existing user knowledge/decisions, provide new knowledge for the user to make a decision/action, or contradict the user's existing knowledge to prevent a wrong

decision or action? Or does the information have no impact on user knowledge, attitudes and behaviour? Where is the impact seen? It could be suggested that as well as a direct measurable impact on the library user there is also an indirect impact on those people and processes affected by the library user's subsequent work. In the healthcare domain, both patients and health professionals have access to physical and digital libraries. Therefore, the impact of these libraries can be directly on each individual, but also indirectly on the other people involved in decisions made about a patient's care. Knowledgeable patients are able to participate more fully in the management of their health, sharing in decision-making with professionals (Health on the Net Foundation 2005; Ziebland et al. 2004). Therefore it is important that we can measure the effectiveness of medical DLs in changing the knowledge and attitudes of both health professionals and the public, subsequent decisions and outcomes, so that the healthcare system can exploit these resources to its best advantage. This applies also to other fields such as business environments where retrieved information and gained knowledge can improve sales/revenue etc or in law where case outcomes could be influenced by improved knowledge.

In addition to measuring knowledge and attitude changes we can gain patterns of use of digital libraries in a way not previously possible with traditional physical libraries. We can track users' activity throughout the library, recording every document, page or file visited or downloaded, unlike in a physical library where we are restricted to knowing only the final transaction of borrowing a book and perhaps the time of entry, rather than the journal articles read or photocopied, those picked up and discarded or "bookmarked" for later reading. This has important implications for evaluating the impact of the library. Understanding user behaviour within the library can help in library development, ensuring that libraries are designed to best serve their user community. For example, supermarkets track user shopping behaviour through loyalty cards, using this information to strategically place items within the store and tailoring special offers to users, the impact here being to improve the ease of the shopping experience for the user and of course increase the number of items purchased. Data obtained from tracking library users' behaviour could be used in a similar way to develop the library to improve the impact it has on its users by providing access to potentially relevant documents and guidance the user may not be aware of.

Another factor influencing the impact of a library is its accessibility to its users. How easy is it for clinicians to use the library to answer their questions within the time constraints they face? One of the previous studies found that the availability and cost of searching Medline may have influenced its response rate across different hospitals (Marshall 1992) and more recent research has suggested that despite the obvious improvement in accessibility of digital libraries

and web resources there are social contexts in which these tools are used which may still constrain their accessibility (Adams & Blandford 2002; Urquhart et al. 2001).

A need therefore arises for investigation into the current state of digital library impact evaluation research and potentially development of a model and framework to provide some consistency in evaluation of these widely varying resources.

1.2 Research aims and objectives

The research aims that follow from this introduction are therefore:

To identify the need for and develop a model and framework for digital library impact evaluation, that when applied will show the impact of a digital library on its user community. This will include:

- developing a new model and framework for impact evaluation across library sectors
- allowing for tailoring of the model/framework by its users to evaluate the impact of the digital library on knowledge and intended behaviour/decision changes
- investigating the barriers to successful use of the digital library to gain an awareness of how the library can be improved to increase its impact

The research objectives below describe steps of the research that when completed will ensure the research has met the above aims:

- I. Review the literature to identify the current status of impact evaluation research in digital libraries
- II. Identify a need for a digital library impact evaluation model and identify requirements for digital library impact evaluation
- III. Develop a model and framework for digital library impact evaluation with a method of producing an impact score
- IV. Implement the model and framework on a case study digital library
- V. Evaluate the model and framework in terms of how well they meet the requirements for a digital library impact evaluation and refine as necessary
- VI. Identify how the model can be developed in future research

1.3 Scope of the research

The scope of this research has boundaries as described below:

- The model will not include, at this stage of development, investigation into objectively measured outcomes such as prescribing rates, alcohol hand gel usage etc. This is beyond the scope of this project which is a preliminary study to develop a model for digital library impact evaluation and is limited due to the funding constraints on the project and the timescale within which it is to be performed. However, there is potential for the model developed in this research to be extended in future work to include measurement of such outcomes.
- The testing of the model will occur in the medical digital library domain as this is where the researcher has knowledge and experience and access to a digital library. Therefore the appropriateness of the data collection methods will only be tested in this domain. However, running more than one evaluation to test the model is outside the scope of the project due to the limited funding and time available for the project. As the model is published and used in other settings it is possible that future evaluations can be used to refine the model if necessary.

1.4 Organisation of thesis

This introduction has provided a background to the research project and described the aims and objectives that will be fulfilled. Chapter 2 reviews the current state of the art firstly by defining digital libraries then focusing on defining evaluation and impact. It then presents a set of requirements for digital library evaluation before reviewing current digital library evaluation frameworks and measures and previous digital library impact evaluations published in the literature. The chapter continues by describing how these evaluations have attempted to measure impact and where this fails to meet with the requirements identified earlier in the chapter. It concludes by presenting methods used in previous evaluations and describing the limitations of this previous research. Chapter 3 presents a new approach using knowledge and attitude as indicators of behaviour. It defines knowledge and attitude and briefly introduces the Theory of Planned Behaviour and Dervin's Sense-Making model that are both used to support this research. It then presents the development of the Impact-ED model of digital library impact evaluation and discusses how this will meet the requirements presented in Chapter 2. Chapter 4 presents the methodology of the research, describing how it will be undertaken and what will be done. The next chapter (chapter 5) presents the results of testing of the model and the calculation of the Impact Score. It discusses the benefits and weaknesses of this score. Chapter 6 describes how the model and template were refined following testing on the case study library, discusses the limitations of the research and presents ideas for potential further work using the Impact-ED model. The thesis concludes with a summary of how this research

has added value to the digital library research domain and how well the research has met the digital library impact evaluation requirements and the aims and objectives of the research.

Chapter 2 – Literature Review

2.1 Introduction

This chapter introduces digital libraries, discusses published definitions and their dimensions, and reviews how these current definitions reflect the dimensions of digital library work. It provides a context for the proposed research and identifies the dimensions on which the evaluative framework will be based. The four dimensions of a digital library as identified by Fox and Marchionini (1999) are community, technology, content and services, and in particular the lack of research around community aspects of digital libraries is highlighted.

It also discusses the meaning of evaluation in a digital library context. Definitions and features of evaluation are discussed and gaps with respect to impact evaluation are highlighted. The importance of determining value in an evaluation and what this means in a digital library context is discussed. It examines digital library evaluation frameworks and measures and identifies gaps in these frameworks. A discussion of what is meant by impact in the context of this research is followed by a literature review of previous individual digital library impact evaluation projects and impact measures used in these projects are identified and discussed. Following this, is a review of methods used in digital library impact evaluations and the chapter concludes with a discussion of the current limitations of these frameworks, project approaches and methods.

2.2 Digital Libraries

2.2.1 Digital library definitions

Defining the term “digital libraries” is not as straightforward as it may first seem. Digital libraries are not simply organised collections of electronic resources, just as traditional libraries are not only organised collections of books. Digital libraries are altogether more complex entities for which there exists no single definition from either the research community or the library and information profession. Borgman (1999) reviewed the literature in 1999 and found that existing definitions fit into one of two groups:

- Those with a focus on access and retrieval of digital content. These definitions are usually provided by the research community.
- Those with a focus on the collection, organisation and service aspects of a digital library. These definitions are usually provided by the library and information profession.

The former group is focussing more on the technology and research aspects of digital libraries whilst the second is more concerned with service delivery. However, given the multidisciplinary nature of digital library research and development (Borgman 1999; Boyack et al 2001) it is inappropriate to neglect either of these groups when considering a definition. It seems that this multidisciplinary nature may be what hinders an inclusive definition as each discipline defines its own concept of a digital library. When defining a concept it is necessary to look at the aspects or dimensions of that concept. Arms (2001) lists in detail what he considers to be the benefits of digital libraries, which may be translated as characteristics, including the constant availability across time and space barriers, the ease of updating information, the potential for information sharing and the powerful information retrieval facilities. Chowdhury and Chowdhury (2003) provide a summary of digital library characteristics that they have identified in the literature, in essence highlighting the ubiquitous nature of digital libraries and the need for control over collection development given the risk of "information overload" in the digital world. Definitions of the term "digital library" identified by the literature review can be found below.

Definition 1: Digital libraries are a set of electronic resources and associated technical capabilities for creating, searching and using information. In this sense they are an extension and enhancement of information storage and retrieval systems that manipulate digital data in any medium (text, images, sounds; static or dynamic images) and exist in distributed networks. The content of digital libraries includes data, metadata that describe various aspects of the data (e.g. representation, creator, owner, reproduction rights) and metadata that consist of links or relationships to other data or metadata, whether internal or external to the digital library. Digital libraries are constructed, collected and organised by (and for) a community of users, and their functional capabilities support the information needs and uses of that community. They are a component of communities in which individuals and groups interact with each other, using data, information and knowledge resources and systems. In this sense they are an extension, enhancement and integration of a variety of information institutions as physical places where resources are selected, collected, organised, preserved and accessed in support of a user community. These information institutions include, among others, libraries, museums, archives and schools, but digital libraries also extend and serve other community settings including classrooms, offices, laboratories, homes and public spaces.

Source: UCLA National Science Digital Library (NSDL) workshop (Borgman et al. 1996)

Definition 2: The collection of services and the collection of information objects that support users in dealing with information objects and the organisation and presentation of objects available directly or indirectly via electronic/digital means

Source: Dlib working group 1998 (Leiner 1998)

Definition 3: Digital libraries are organizations that provide the resources, including the specialized staff, to select, structure, offer intellectual access to, interpret, distribute, preserve the integrity of, and ensure the persistence over time of collections of digital works so that they are readily and economically available for use by a defined community or set of communities

Source: Digital Library Federation (DLF) (Waters 1998)

Definition 4: A distributed library information service, located either in a physical or virtual space, or a combination of both, in which a significant proportion of the resources available to users exist only in digital form

Source: Rowlands & Bawden (1999)

Definition 5: There are many definitions of a “digital library.” Terms such as “electronic library” and “virtual library” are often used synonymously. The elements that have been identified as common to these definitions are:

- the digital library is not a single entity;
- the digital library requires technology to link the resources of many;
- the linkages between the many digital libraries and information services are transparent to the end users;
- universal access to digital libraries and information services is a goal; and
- digital library collections are not limited to document surrogates: they extend to digital artefacts that cannot be represented or distributed in printed formats.

Source: Association of Research Libraries (ARL) (Cullen 2003)

Definition 6: A digital library is an ongoing concern; is a collection of resources (organised content), including navigation and finding tools, in a distributed networked environment; is a set of services and meets end users’ needs

Source: Delphi study (Kochtanek & Hein 1999)

Definition 7: Systems providing a community of users with coherent access to a large organised repository of information and knowledge

Source: Clifford Lynch (Norman 1997)

Definition 8: A managed collection of information, with associated services, where the information is stored in digital formats and accessible over a network.

Source: William Y. Arms (Arms 2001)

But how well do these definitions reflect what a digital library does? That is its work? The next section presents two digital library work models and discusses how well these definitions reflect the dimensions of digital library work.

2.2.2 Digital library work models

Two digital library work models were identified in the literature (Fox & Marchionini 1999; Rowlands & Bawden 1999). These models identify different dimensions to digital libraries and their work. They were the only diagrammatic models identified in the literature review to reflect the different dimensions of a digital library and its work. The reason for discussing these models is to gain an understanding of the different dimensions of a digital library and how these may interact and subsequently to inform the development of the evaluation framework.

The first model is proposed by Rowlands and Bawden (1999). In a review of research into digital libraries they adapt Yates' work-oriented library model for digital libraries (Figure 2.2.2a), highlighting three aspects to digital libraries:

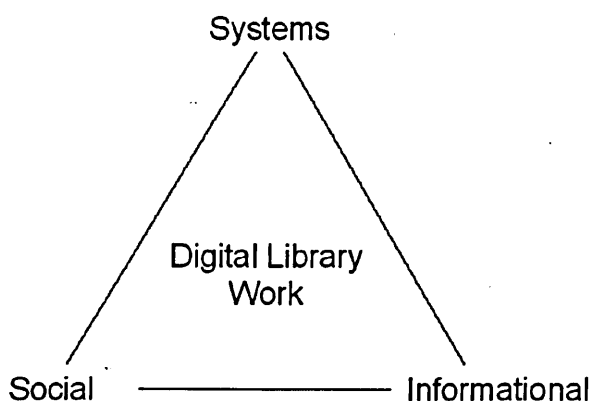


Figure.2.2.2a - Rowlands and Bawden's adaptation of Yates' model (taken from (Rowlands & Bawden 1999))

- Social (replaces “work” in Yates’ model) e.g. information skills and literacy, impact on work, information law and policy
- Informational (replaces “documents”) e.g. knowledge organisation and discovery
- Systems (replaces “technologies”) e.g. human-computer interaction, information retrieval

As this is a model based around digital library research at this time, this may explain a lack of emphasis on the user community. Fox and Marchionini (1999) highlight a lack of research in this area and provide their own model (Figure 2.2.2b) in which they identify the current state of research (in 1999) in four dimensions to digital library work:

- **Community** e.g. needs, information seeking behaviours and attitudes of user community. Borgman et al (1996) emphasise the role of user communities in creating digital libraries to support their communities, a view supported by Arms who believes that some of the most successful digital libraries are created by researchers or groups of professionals for themselves and their colleagues (Arms 2001). Geudon (1999) takes a rather more romantic view suggesting that librarians should not see themselves as knowledge bankers focussing purely on content but rather as “hearts dynamising human communities”.
- **Services** (matches to both “informational and social” in Rowlands & Bawden’s model)
- **Technology** (broadly matches to “systems”)
- **Content** (broadly matches to “informational”). In a digital library content should be mostly digital although some digital libraries may contain reference to non-digital content (Rowlands & Bawden 1999).

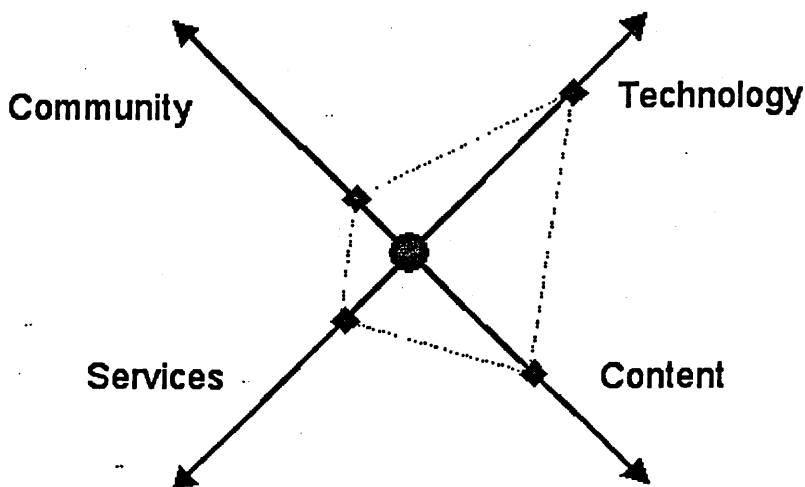


Figure 2.2.2b Fox & Marchionini Model of Research in Digital Library Dimensions (taken from(Fox & Marchionini 1999))

The model shows most research activity occurring in the technology and content dimensions of digital library work. But how are these dimensions reflected by the definitions in the literature presented above? Table 2.2.2 shows how each definition reflects each dimension. The technology dimension of digital library research is reflected in seven of the eight definitions, whilst all eight refer to the content and six to services. Only half refer to the user community. This matches broadly to the model of research in Figure 2.2.2b the exception being the lack of emphasis on services in the research whilst it was referred to in six of the definitions. This is most likely due to this model being published at a time when research into digital libraries was not well established and at an early stage. Research was perhaps driven more by the technology research community concerned with development issues rather than active use of the resource by its user community.

Definition	Source	Community	Services	Technology	Content
1	UCLA NSDL workshop (Borgman et al 1996)	✓	✓	✓	✓
2	Dlib working group 1998 (Leiner 1998)		✓	✓	✓
3	Digital Library Federation (Waters 1998)	✓	✓		✓
4	Rowlands & Bawden (Rowlands & Bawden 1999)		✓	✓	✓
5	Association of Research Libraries (Cullen 2003)		✓	✓	✓
6	Delphi study (Kochtanek & Hein 1999)	✓	✓	✓	✓
7	Clifford Lynch (Norman 1997)	✓		✓	✓
8	William Y. Arms (Arms 2001)		✓	✓	✓

Table 2.2.2 - Definitions of "Digital Library" identified by a literature review and how they reflect the dimensions of a DL

Whilst these models are useful in identifying the different dimensions to digital library work and how well current definitions are reflecting the whole concept of a digital library and its activity, they provide little information about how these dimensions fit together, rather focussing on each as a separate entity. This approach may be appropriate for identifying the state of current research, as was the intention behind these models, but for the purposes of this research it is necessary to take a closer look at the interactions between the dimensions. When evaluating the impact of a digital library one cannot take each dimension in isolation, as each will influence the other. All dimensions have the potential to influence the impact of the digital library on the user either directly or indirectly through their interactions with each other. Therefore any proposed model for digital library impact evaluation will have to take into account the interactions between the dimensions and should be developed around these. This section has discussed digital library definitions and dimensions to provide a context for the proposed research.

In summary a digital library consists of a collection of resources and services provided to a user community by an underlying technology. Digital libraries are typically dynamic entities with all dimensions (content, services, technology and community) changing frequently (if not continually) throughout its lifetime. So now we know what we are evaluating the impact of, the next section focuses the literature review on a specific area of digital library research, develops requirements for digital library impact evaluation, reviews current digital library impact evaluation research to see how well previous evaluations fit these requirements and identifies the gap which this research will attempt to fill.

2.3 Digital Library Evaluation

2.3.1 Defining Evaluation in a Digital Library Context

Evaluation in a digital library context can be either summative, where the aim is to see how well a library performs i.e. how good it is, or formative, where the aim is to see where it can be improved (Bawden 1990). Blandford et al (2008) describe the former as the approach most often used by the Information Retrieval Community and the latter as the approach taken by the Human Computing Interaction Community. The formative method allows an iterative approach where different versions of the library are developed based on the results. This is perhaps best suited to the digital library domain where libraries are continually changing and developing as technology moves on. Chowdhury & Chowdhury (2003) define evaluation as a judgement of worth to ascertain a level of performance or value. Saracevic (2000b) takes this further suggesting that performance can be broken down into two criteria:

- Effectiveness i.e. how well does a system perform that for which it was designed?
- Efficiency i.e. at what cost (financial or time/effort)?

He also discusses the meaning of value, suggesting that in the library domain value tends to be seen as economic justification (Saracevic & Kantor 1997). To illustrate this, an evaluation looking at a combination of the above criteria is an assessment of cost-effectiveness. Saracevic goes on to propose three sets of digital library evaluation criteria (Saracevic & Covi 2000):

- Library criteria e.g. collection issues, information accuracy, representation, library use, accessibility, library standards
- Information retrieval criteria e.g. relevance, satisfaction, index and search features
- Human-computer interaction/interfaces criteria e.g. usability, reliability, design features, navigation, services/help

Most of these criteria are concerned with knowledge organisation and retrieval and how well the system performs, with little emphasis on services provided and the digital library community. Marchionini et al (2003) identify the importance of evaluation in the context of the digital library community, "All efforts to design, implement and evaluate digital libraries must be rooted in the information needs, characteristics and contexts of the people who will or may use those libraries". He also believes the ultimate aim of digital library evaluation is to assess the impact on patron's lives (Marchionini 2000). Borgman (2003) also highlights the importance of the user and social factors in digital library evaluation but suggests there is still a lack of successful digital library impact evaluations (Chowdhury et al 2006).

Saracevic also discusses different levels of value in the context of library evaluation (Saracevic & Kantor 1997). Value on a social level is value that a service provides to the society or community. Value on an institutional/organisational level is value linked to the mission or progress of the institution. Finally value on an individual level is the value of a service to individuals or groups of users needs. These are all interrelated and whilst he acknowledges that most digital library evaluations are on the individual level (Saracevic & Covi 2000) the impact of a library on individuals accumulates to an impact at an institutional or social level. He also believes that digital libraries are too complex to be evaluated as one entity and that smaller evaluations focussing on different aspects of the digital library are more appropriate (Saracevic 2000b). In a similar approach Missingham (2001) discusses value in terms of the value placed on a digital library by its users and the value of the collection and services provided in relation to the desired outcomes of the library, i.e. its impact.

The Tavistock Institute was commissioned to undertake an evaluation of the eLib program, a UK project that aimed to increase and accelerate the uptake of electronic media and network

services in UK Higher Education libraries. They decided there were five important points to take into account when evaluating an open-ended developmental project such as eLib with a wide range of stakeholders (Kellerher et al 1996). These are listed below:

1. The evaluation should contribute to the collective learning i.e. contribute to future decisions and choices
2. It should take into account the views and perspectives of different stakeholders
3. The local projects that were part of the eLib programme needed to collate results to make available to all stakeholders
4. Evaluation should follow the entire life cycle of a project and not just the effects and outcomes
5. The evaluation should contribute to networking and knowledge transfer

Whilst this list was developed for evaluation of a project rather than a digital library as a service or entity, it is relevant for digital library research. It supports the emphasis Marchionini (2000) and Borgman (2003) place on the user community and their approach to formative evaluation where evaluation is an integral part of digital library design and development (Borgman et al. 2000; Marchionini & Crane 1999).

Clearly evaluation involves measuring in some way the value or impact of the digital library but despite the emphasis placed on value by the research discussed above there is little evidence of measurement of this value or impact in current digital library research. This is perhaps due to the complexity of digital libraries and their wide range of users (Chowdhury et al 2006) resulting in impact evaluation research being limited to specific digital library projects rather than attempting to create standards or frameworks for evaluation. Whilst there has been significant work towards developing performance measurements and usage statistics for digital libraries, these "value" measurements have tended to focus on user satisfaction and performance targets of the digital library rather than any investigation of impact on users as discussed in the next section.

2.3.2 Current Digital library & electronic information services evaluation measures and frameworks

The table below (Table 2.3.2) shows the eight frameworks identified following a literature review that included measures for evaluating digital libraries. Six of these eight were purely

quantitative measures whilst the NSDL guide (Reeves et al 2003), included both quantitative and qualitative measures and the Evalued project contained mainly qualitative measures (McNicol 2004).

Framework	Developer	Methods	Comments	References
CAPM	John Hopkins University	Quantitative measures. The CAPM (Comprehensive access to printed materials) methodology is a preference analysis framework developed to evaluate user preferences for a robotic system to retrieve, scan and deliver documents and articles from remote locations.	Can be used in conjunction with Libqual TM or Digiqua TM where the latter are used to identify gaps in service and the former to identify user preferences to fill those gaps.	(Choudhury et al. 2002)
Digiqua TM 2004-2006	Association of Research Libraries (ARL)	Quantitative measures. Online survey where 5 survey questions drawn randomly from a question bank depending on categories selected by library owner. One fixed question asks about user satisfaction. All questions have a 7 point Likert scale & all results are processed by the Digiqua TM team and returned to library owners as a report.	Adaptation for digital collections of the Libqual+ TM tool from the ARL used to measure user satisfaction and service quality of libraries. Libqual+ TM was based on Servqual, a tool used by private sector companies to evaluate service quality	(Digiqua 2006; Choudhury, et al 2002)

Framework	Developer	Methods	Comments	References
E-measures 2003-2004	Evidence Base, University of Central England Hefce funded project	Quantitative measures. 17 Performance indicators covering collection availability, usage and cost	Developed to assist librarians in decision-making and user support and provide performance indicators for Electronic Information Services	(Conyers 2004)
E-metrics 2000-2003	Association of Research Libraries (ARL)	Quantitative Measures. 20 Performance measures covering collection availability, usage of the collection, usage compared to usage of print collection and cost	Phases 1 & 2 concerned with purely quantitative measures. Forthcoming phase 3 looking at outcomes.	(Miller & Schmidt 2001)

Framework	Developer	Methods	Comments	References
Equinox 1998-2000	European Union funded project with 7 European partners from the UK, Ireland, Spain, Germany & Sweden	Quantitative measures. 14 performance indicators covering usage statistics, cost, the physical library providing the electronic collection and user satisfaction	Developed performance measures for physical libraries to include measures for the electronic library environment	(Clarke 2000)
Evalued 2003-2005	Evidence Base, University of Central England	A toolkit for HE libraries developed alongside the Emeasures project. Mostly qualitative with some quantitative measures Focuses on 3 themes: Planning, management and impact. Uses a variety of methods including interviews, focus groups, questionnaires, critical incident technique.	Allows users to select tools for areas they are interested in evaluating. Provides tools for evaluating various aspects of service e.g. collaboration between libraries and academic departments, collection availability, staffing issues, costs, technical performance, impact on learning and teaching (e.g. citations in coursework & how staff help students find articles) and on graduate skills and research.	(Evidence Base 2006)

Framework	Developer	Methods	Comments	References
MINES for Libraries TM 2003-2006	Association of Research Libraries (ARL)	Quantitative measures. Mines (Measuring the Impact of Networked Electronic Services) for Libraries TM uses an online survey to collect data about the purpose of use of electronic resources and user demographics.	Been used by over 30 North American Libraries as part of the project, one of which was an academic health library. Showed users were using Electronic Services for teaching and research rather than patient care in this instance. It enables libraries to see which user groups are accessing which resources from where.	(Franklin & Plum 2006)
NSDL Guide to Evaluating Digital Libraries 2003	National Science Digital Library (NSDL)	A handbook providing information on various methods for evaluating digital libraries e.g. transaction log analysis, surveys, interviews, focus groups, observations.	Covers service evaluation, usability testing, biometric evaluation, information retrieval. Comprehensive and clear guide.	(Reeves et al 2003)

Framework	Developer	Methods	Comments	References
Pret A Rapporter	UCL Interaction Centre & School of Library, Archive & Information Studies (SLAIS) at UCL	A six step framework to be used for planning evaluations of digital libraries and similar systems. Outlines the steps involved in undertaking an evaluation i.e. deciding the purpose, identifying resources and constraints, ethical issues, techniques for data capture, analysing the data, and reporting the data.	Has a Human-Computing Interaction focus i.e. the usability and information retrieval capabilities of the system.	(Blandford et al 2008)

Table 2.3.2 Current digital library and electronic information service evaluation measures and frameworks

The frameworks identified were mostly aimed at academic libraries and the focus tended to be on physical libraries with digital or electronic collections rather than completely digital libraries (with the exception of the NSDL guide and Pret A Rapporter framework which were aimed at all digital libraries). The key emphasis of most of the frameworks and their measures is on statistical measures e.g. usage statistics and satisfaction ratings. MINES for Libraries TM begins to look at where and why people are using the library but does not explore this in any depth or attempt to investigate whether it makes a difference to the user's work or information need. A different approach was taken by Blandford et al (2008) who, in developing the Pret A Rapporter framework consider how Information Retrieval systems (including digital libraries) can be evaluated to assess how well they fit with users' work. Whilst investigating how digital libraries can be improved by asking users, this is not an impact study. Another study (Xie 2006) asked users to specify criteria for digital library evaluation finding that usability and collection quality were classed as the most important criteria but again there is no discussion of the actual impact the digital library is having on user work.

No real attention is given in any of these frameworks to including generic criteria to investigate the impact of the digital library on end users' work. There are some beginnings towards including this in the Evalued project but this focuses on the academic physical library with digital resources e.g. a suggested impact measure is analysing citation rates in student coursework, a method used in the Perseus evaluation (Marchionini & Crane 1999) described in Section 2.3.4. However this is a very specific method for academic libraries and not something particularly practical for digital libraries whose users are spread geographically and perhaps anonymous. Measuring the impact of these digital libraries will require different methods. The Emetrics framework claims to have a third phase looking at outcomes for which the literature did not provide any further information. When the Association of Research Libraries was contacted to provide more detail about this phase they revealed that the outcomes phase was about evaluating how libraries meet their targets rather than the outcomes/impact of the library within its community. There is clearly therefore, a gap in current evaluation frameworks for a digital library impact evaluation framework. Before developing such a framework however it is necessary to define what we mean by impact and what we are trying to measure. The next section discusses definitions of impact, how it relates to digital libraries and presents requirements for an ideal digital library impact evaluation.

2.3.3 Defining Impact

It is not enough to simply evaluate use of a digital library or user satisfaction. Fox & Marchionini's model (Figure 2.2.3b) highlighted the emphasis of digital library research in the technology and content dimensions and the same could be said of evaluation (Fox &

Marchionini 1999). Van House et al agree that usability studies usually only evaluate the user interface which is not sufficient evaluation for something as complex as a digital library (Van House et al. 1996). They believe that the library must have an impact on the user's work. However, the notion of measuring impact on the user is missing from most of the frameworks presented in Table 2.3.2 despite the emphasis placed on impact by Saracevic and others when discussing digital library evaluation (Chowdhury et al 2006; Marchionini 2000; Saracevic 2000a; Saracevic & Kantor 1997).

But what is impact? What are we trying to measure? Impact can be defined simply as "The effect or impression of one thing on another" (Definition of Impact 2006). This implies that evaluating the impact of a digital library is evaluating the effect or impression it has on its users. "Impression" implies more than satisfaction, or the opinion a user might have, but a physical impression such as the ripples a stone might make in the water into which it is thrown. A digital library can make such ripples, be it in user knowledge and attitude change or changes in clinical decision-making. The aim of this research is to evaluate them.

A more comprehensive definition of impact in terms of an intervention is given by Blankenberg (1995):

'Impact concerns **long-term** and **sustainable changes** introduced by a given intervention in the lives of beneficiaries. Impact can be related either to the specific objectives of an intervention or to unanticipated changes caused by an intervention; such unanticipated changes may also occur in the lives of people not belonging to the beneficiary group. Impact can be either positive or negative, the latter being equally important to be aware of.'

This definition extends the idea from impact being simply a small change in knowledge to being a long-term change on the user that is not necessarily positive. This kind of impact is extremely hard to measure in digital library evaluation due to the potentially diverse nature of a digital libraries' user base and the difficulties of identifying long-term impacts on these users. So far digital library impact evaluations have either been one off projects (Chowdhury et al 2006) or an attempt to integrate impact evaluation into digital library design (Borgman et al 2000; Marchionini & Crane 1999). The latter is a form of long term impact evaluation where repetitions of the evaluation as a library is developed to provide a picture of how the library is both improving its immediate impact and being integrated into user work or learning over time. An illustration of how a library's impact can be seen over time is given by perhaps the most famous

historical library, the Alexandria library. The impact this library has had on human development and society is huge and evident in today's society in the following ways (Whitehouse 2004):

- Archimedes invented the screw type water pump that is being used today.
- Eratosthenes measured the diameter of the Earth
- Euclid discovered the rules of geometry
- Ptolemy wrote the *Almagest*, the most influential scientific book about the nature of the Universe for 1,500 years

These are examples of specific results of using the library. Whilst we may not expect individual digital libraries to have such definable single impacts on modern society they can surely have a great impact on modern society as a whole. The key message is that impact is not purely about the short-term but also the long-term sustainable change. For example, is use of the digital library changing a clinician's work practice rather than just helping them on one or two occasions? Does the library provide information that is used as evidence for writing better policies and guidelines for future practice? Is what it provides being embedded in the user's work? Evaluation of digital library impact should involve investigation into the longer-term effects on the user rather than just short-term changes in decision-making therefore any framework should allow comparison of impact over repeated evaluations.

Some work is underway to evaluate impact of academic libraries on teaching, learning and research (Everest & Payne 2001; Payne & Conyers 2004), however there is no model or framework for evaluation and this research has yet to be applied to the digital library environment. As already discussed in 2.3.2 the Evalued project begins to address this issue but focuses mainly on cost and management issues with limited evaluation of impact on teaching and learning. A Library and Information Research Group seminar in 2001 concluded that measuring impact was not an exact science, but that it was important to define your audience and your success criteria as these are necessary to focus your evaluation research, and not to ignore negative impacts (Everest & Payne 2001). These thoughts were echoed more recently by Christine Urquhart (Urquhart 2005). It is important to investigate what features and services of a library are having what impact and how they can be improved to increase the impact of the library. Evaluating the impact of a DL will require new evaluation models if the impact on users' work and decision-making is to be identified and compared over time.

2.3.4 Defining the requirements for a digital library impact evaluation

Applying the definitions of impact discussed above to digital libraries a digital library impact evaluation should identify:

- I. The effect or impression of the digital library on the user and their work i.e. what the library means to users and what difference it makes to their work
- II. The short and long-term changes the library makes to the user and their work i.e. the difference the library makes to user work both immediately at the point of use and over time as the work the library helped the user complete/achieve is implemented
- III. How the library is being used to help the user in their work i.e. for what reasons is the library used and how does it help?
- IV. The relationship between library features and services and the library impact and how they can be improved to increase impact i.e. formative evaluation to see if there a difference in the impact of the library depending on which services or features are utilised by the user and how can these services and features be improved to increase library impact?

In addition the ideal evaluation should evaluate real-time, real-world use by real users i.e.

- V. Real-time – measure impact at the point of the visit to the library not retrospectively by relying on user recall but as they visit
- VI. Real-world – measure impact of an active digital library in an actual world setting not a simulated environment or test library
- VII. Real users – measure the impact on actual users of the library as they visit for their own needs not just people recruited to take part in a study and visiting to complete scenario-based tasks
- VIII. Finally the impact of a digital library should be quantifiable and the ideal evaluation should enable calculation of an impact score so that libraries can be compared over time and also potentially with each other.

So how does current research measure up to these requirements for digital library impact evaluation? The next section presents the results of a systematic review of digital library impact evaluations and discusses where they are currently lacking as compared to these requirements.

2.3.5 Review of previous digital library impact evaluations

A systematic review of previous digital library impact evaluations was undertaken to identify the current state of research in this area. The search strategy and inclusion and exclusion criteria are described in Section 4.2. The literature review identified sixteen studies where the impact of digital libraries was evaluated. Thirteen of these were in the medical domain. All sixteen are presented below with a description of the digital library, the population studied and the results of the impact evaluation and the way in which impact was measured.

Digital Library: Clinical Information Access Program (CIAP)

Where published: Westbrook et al (2007) and Gosling et al (2004)

Description: An evaluation of an Australian online clinical evidence resource

Setting: New South Wales, Australia, but not clear which hospitals.

Population: First study surveyed nurses (Gosling et al 2004) and the second more in-depth study (Westbrook et al 2007) was investigating experienced users of CIAP (13 doctors and 16 clinical nurse consultants)

Methods: Questionnaire (Gosling et al 2004) and semi-structured interviews (Westbrook et al 2007). Interviews were in two parts; one using the critical incidence technique to discover why people were using CIAP and the other journey mapping to investigate how and with what result. Responses were mapped to a 12 stage journey scoring points for each stage reached. This was part of a wider study into use of CIAP using questionnaires and web logs.

Results: In the questionnaire nurses reported potential for CIAP to impact on patient care. In the interviews nurses reported more impact on policy changes and patient education whilst doctors reported more impact on treatment decisions and patient education. Nurses reported few major impacts whilst doctors reported improvements in patients' health, a life saved on two occasions and prevention of unnecessary procedures or treatment. CIAP was more integrated into doctors' practice than nurses.

Measure of Impact: Self-reported major and minor impacts. Analysis by journey mapping provided some insight into how integrated CIAP was into work practices.

Impact not measured: The relationship between library features and services and the library impact and how they can be improved to increase impact, not a real-time study i.e. relies on user recall; no impact score.

Digital Library: Clinical Information Network (CLINT)

Where published: Nankivell et al (2001)

Description: Pilot project to introduce networked information resources into clinical settings in a large NHS Trust and the impact on clinical decision-making

Setting: Birmingham Heartlands and Solihull NHS Trust

Population: First questionnaire survey 137 hospital staff (consultants or registrars 68.6%, 14.6% junior doctors) Second interview survey 21 CLINT users

Methods: Pre-network questionnaire, analysis of network use (recorded online activity of 30 users), post-network interviews.

Results: The pre-network survey identified MEDLINE as a reliable source of information for medical research, clinical decision-making, supported by the access to MEDLINE by the 30 online users who were tracked. It was used more frequently and for longer than any other resource. Six interviewees reported making different decisions on treatment or diagnosis as a result of accessing CLINT and some said they might use it in the future for decision-making but hadn't had sufficient time or experience using it yet to know for certain.

Measure of Impact: Self-reported retrospective and prospective impact of CLINT on decision-making.

Impact not measured: The relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score

Digital Library: Cochrane Library

Where published: Forbes et al (2007)

Description: evaluation of the impact of the provision of The Cochrane Library to residents of Saskatchewan

Setting: Saskatchewan, Canada

Population: Library staff (36.9%) nurses (16.3%) therapists (7.6%), pharmacists (4.3%), physicians (3.3%), other health care providers (20.7%) in Saskatchewan and other Saskatchewan residents (9.8%) who attended training sessions in the use of the Cochrane Library.

Methods: Telephone questionnaires three, six, nine and twelve months after the training session. Collection of access data from the publisher of The Cochrane Library.

Results: Access fell over the 12 month period (both reported & actual). Most respondents claimed to have learned something from the library (57.5%), that it helped decision making (32.6%) confirmed beliefs (26.11%) although no actual numbers are provided just percentages so it is not clear if this is a percentage of users who access the library or those who took part in the study. Also few users were clinical staff.

Measure of Impact: Self-reported answer to telephone questionnaire.

Impact not measured: The relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score.

Digital Library: Critical Appraisal Resource (CAR)

Where published: Crowley et al (2003a)

Description: Electronic database of clinical questions and medical evidence

Setting: Inpatient general medicine wards at Duke University Medical Center and the Veterans Administration Medical Center in Durham, North Carolina

Population: 82 residents (some participating more than once as they rotated on the general medicine wards more than once)

Methods: As residents entered a clinical question (CQ) they were also prompted for demographic information, patient diagnosis, the resource used to find the answer, and the impact of the information on patient care decisions.

Results: Useful information from the medical literature confirmed patient care decisions in 53% of cases and changed patient management in 47% of cases. In 49% of the latter cases, the

altered care decision involved a medication change, 26% a change in diagnostic test and 13% a change in prognosis communicated to the patient.

Measure of Impact: Self-reported impact of information on decision-making. Specific to a situation

Impact not measured: The effect or impression of the digital library on the user and their work; the relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score.

Digital Library: Federal Science eLibrary

Where published: Brown et al (2007)

Description: Evaluation of a pilot project for the Federal Science eLibrary for Canadian Government Researchers

Setting: Three Canadian government sites where users had access to the pilot project

Population: 500 Canadian government researchers (90 of which returned the main questionnaire and 48 the impact questionnaire)

Methods: Questionnaires, including an impact questionnaire at the end of the pilot, usage statistics, correspondence/ teleconferences with the pilot librarians

Results: 80% felt the impact of access to the library on their research and productivity was positive or very positive, specifically in keeping up with the literature and read more widely, meeting tight deadlines, equality of access, environmental benefits, being able to reach all content from one gateway.

Measure of Impact: Qualitative self-reported impact on work

Impact not measured: The relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score.

Digital Library: Forest Healthcare Trust Intranet

Where published: Freeth et al (2001)

Description: 24-hour access to library materials in clinical areas

Setting: Forest Healthcare NHS Trust, North Thames region

Population: Stage 1 questionnaire - 110 doctors

Stage 2 Questionnaire – 73 doctors (59 of which completed the first questionnaire)

Methods: Two stage questionnaire to explore changes in the use of online materials, perceptions of the strengths and weaknesses of online resources in clinical areas and changes in practice resulting from the use of online materials

Results: At stage 2, ten respondents (16%) identified 11 examples of changed practice which 19 (31%) considered there were none so far.

Measure of Impact: Self-reported examples of impact of access to library materials on clinical practice

Impact not measured: The relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score.

Digital Library: MDConsult

Where published: Cohn et al (2003)

Description: Evaluation of the MDConsult Digital Library and an aim to provide a model for future digital library evaluations

Setting: Claude Moore Health Sciences Library, University of Virginia

Population: Registered MDConsult users i.e. physicians

Methods: Usage data and registration data, anonymous survey and interviews.

Results: 232 respondents plus 156 non-registered users that were excluded. Overall most MDConsult users agreed or strongly agreed that MDConsult has contributed to their teaching and learning and improved patient care decisions.

Measure of Impact: Self reported impact, Likert scale question.

Impact not measured: How the library is being used to help the user in their work; The relationship between library features and services and the library impact and how they can be improved to increase impact. Not a real-time study i.e. relies on user recall. No impact score.

Digital Library: NASA Astrophysics Data System Digital Library

Where published: Accomazzi et al (2005)

Description: Impact of the NASA ADS digital library on astronomical research.

Setting: URANIA – bibliographic system in astronomy

Population: Worldwide astronomers

Methods: Usage data from web log statistics

Results: The authors estimate that the ADS digital library has an impact of an equivalent of 736 full-time researchers based on the time it would have taken to find the information should ADS not have been available (utility time).

Measure of Impact: Utility time

Impact not measured: The effect or impression of the digital library on the user and their work; the short and long-term changes the library makes to the user and their work; how the library is being used to help the user in their work; the relationship between library features and services and the library impact and how they can be improved to increase impact.

Digital Library: On-Line Electronic Help (OLEH)

Where published: Berkenstadt et al (2006)

Description: a point of care information system for anaesthesia providers prepared by the European Society of Anaesthesiologists

Setting: 12 simulated clinical scenarios, 4 different university affiliated anaesthesia departments in Israel

Population: 48 Anaesthesiologists (28 male 20 female) (24 junior, 12 senior residents and 12 board-certified)

Methods: Each participant was presented with the 12 scenarios. They had access to the OLEH for six. These six were assigned randomly for each participant. Two senior anaesthesiologists evaluated the answers independently and were blinded to the availability of the OLEH. Differences between the reviewers were evaluated by a 3rd expert.

Results: Statistical tests performed to evaluate significance of the OLEH. The availability of the OLEH was associated with higher scores in 11 scenarios and a decrease in the incidence of critical errors in 10. Using the OLEH only increased the time taken to complete the task in one scenario. Professional experience was associated with better scores in 5 scenarios and a reduced occurrence of errors in 3.

Measure of Impact: Measuring user ability to use an online information resource to improve clinical decision-making and reduce potential errors by using clinical scenarios. Further research is underway to determine how the OLEH can impact in a simulated clinical environment.

Impact not measured: How the library is being used to help the user in their work; the relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-world study – occurs in a simulated environment and is not using real users visiting the library with real needs.

Digital Library: OTSeeker

Where published: Bennett et al (2007)

Description: Evaluation of an online library for Occupational Therapists containing critical appraisals of trials and document ranking according to methodology quality.

Setting: Website with a worldwide user-base mainly from Western countries including Australia, USA, Canada, UK.

Population: Mostly occupational therapists (93%) and mostly from the UK, Australia, USA and Canada (80%).

Methods: Online questionnaire with 5-point Likert scale questions placed on the website that launched when a user searched the database for one month. The questions were focusing on how OTSeeker is used in practice and self-reported impact on knowledge changes and clinical practice.

Results: 62% felt it improved their ability to locate research, 19% reported changes in practice, what changes were not specified but these changes were associated with perceived employer support to use databases during work and frequency of Otseeker use. 38% indicated that

information provided had generally improved their knowledge or for 15% confirmed what they already were doing. 19% could not find enough relevant information to change practice.

Measure of Impact: Self-reported Likert scale questions, no specifics provided

Impact not measured: The relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score.

Digital Library: Perseus Digital Library

Where published: Marchionini & Crane (1999)

Description: Evaluation of the Perseus project including an investigation into its impact on teaching and learning.

Setting: Pilot project of a resource developed to provide translations and information in the Classics

Population: Students and instructors

Methods: Observations, questionnaires, interviews and document analysis

Results: Qualitative results showing that Perseus had an impact in terms of providing students and instructors with mechanical advantage e.g. providing information more quickly than users would find it without Perseus, analysing text of information (word lookups) and enabling new kinds of teaching and learning. Perseus was not found to change overall student performance on translations or essays but did allow some students to produce superior arguments.

Measure of Impact: No measure, just qualitative responses and analysis of student translations and essays.

Impact not measured: The relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score.

Digital Library: Shared Hospital Electronic Library of Southern Indiana (SHEL SI) project

Where published: Richwine & McGowan (2001)

Description: a virtual health sciences library in rural Southern Indiana

Setting: Sixteen hospitals, one mental health clinic and a rural health clinic in Southern Indiana.

Population: 39 physicians, 45 nurses, 6 physician assistants, 20 other (e.g. physical therapists, optometrists)

Methods: Form based questionnaire followed by structured interviews with 17 physicians, 1 physician's assistant, 1 nurse practitioner.

Results: Reasons for accessing (in order) personal education, information to support patient care, research and patient education. 75% respondents to questionnaire said the information obtained enabled them to handle a clinical situation differently with the degree of importance of this change averaging 7 out of 10.

Aspects of patient care most influenced by the information were advice given to patients, choice of treatment, choice of drugs and choice of tests. Respondents were asked whether they felt possible adverse events were avoided by information access. The primary perceived positive impact was reduced need for additional tests and procedures. Other areas included reduced medication errors, reduced need for additional outpatient visits and reduced need for hospital admissions. Interviewees also felt knowledge-based information had the potential to positively impact adverse events in hospitals.

Measure of Impact: Self-reported impact on clinical decision-making of electronic information in general. Not Critical Incident Technique. Also perceived expectations of how electronic information could impact on patient care.

Impact not measured: The relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score.

Digital Library: SWICE (South West Information for Clinical Effectiveness)

Where published: Yeoman et al (2004)

Description: Evaluation of the SWICE e-library and its impact on the South West Workforce development and patient care

Setting: Southwest Workforce Development Confederation (South West UK)

Population: Users of the SWICE service & training sessions (mostly NHS staff in the South West UK)

Methods: Online and postal questionnaire

Results: 32.1% reported to use the resource for direct patient care, 51.4% for CPD, 34.9% added to general knowledge and 11.9% passed information onto a patient and signs from the interviews that users are using information from SWICE to support changes in team management and practice

Measure of Impact: Self-reported impact on knowledge and patient care and work practice both from interview and questionnaire (multiple choice)

Impact not measured: The effect or impression of the digital library on the user and their work; the relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score.

Digital Library: Toronto's University Health Network (UHN) Virtual Library

Where published: Sidlofsky et al (Sidlofsky et al 2003)

Description: User study of users of the UHN's virtual library

Setting: UHN is a teaching hospital affiliated with the University of Toronto with four sites all in downtown Toronto."

Population: 585 responses, 17.6% physicians and residents, 15.5% other health professionals, 14.2% nurses

Methods: Online survey for 1 month consisting of multiple-choice, Likert scale and open-ended questions. 585 responses (28.4% response rate based on user access statistics)

Results: 96.8% of physicians stated resource provided relevant and reliable information for their research or teaching, 68% stated it influenced overall advice they gave to patients.

Measure of Impact: Self-reported impact on clinical practice or research and teaching.

Impact not measured: The relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score.

Digital Library: Value & Impact of Virtual Outreach Services (VIVOS) project

Where published: Yeoman et al (2001)

Description: aim to develop and evaluate methodologies for determining the effectiveness of the virtual outreach services which underpin the National electronic Library for Health (NeLH now NLH www.library.nhs.uk)

Setting: 7 sites investigating different services provided by the NeLH:

Leicester: 24 hour access to NISS Biomed

Salford & Trafford: 3-day training program as part of e-STABLISH project

Cornwall: database training sessions for community staff

Bury St Edmunds: the pink book

South Humber: Evidence Matters and access to CINAHL

North Thames: additional data analysis for a database access project survey

Exeter: services provided via library Web page

Population: Healthcare workers across the 7 sites including medical staff, nurses, PAMs, management staff, administrators.

Leicester: randomised stratified sample of 80 potential interviewees of which 35 were interviewed, randomised stratified sample of 175 surveyed (response rate 39.4%)

Salford & Trafford: randomised stratified sample of 20 for interviews, questionnaires sent to remainder of staff who attended training (response rate 46.3%)

Cornwall: randomised stratified sample of 26 for interviews,

Bury St Edmunds: random sample of 23, 14 as expert informants, questionnaires sent to 100 users selected as stratified sample (35% response rate)

South Humber: randomised stratified sample of 22 (15 Evidence Matters users and 7 CINAHL users),

North Thames: 121 users (20% of registered users)

Exeter: Stratified random sample of 200 users with 87 replies (43% response rate)

Methods: Some questionnaires and across all areas 137 interviews. Most interviews were semi-structured face-to-face, only 9% were telephone interviews. Critical incident techniques and vignettes were used.

Leicester, Salford & Trafford, Bury St Edmunds: Interviews and Postal Questionnaires

Cornwall, South Humber: Interviews

Exeter, North Thames: Questionnaires

Qualitative data was analysed using a Grounded Theory approach with NUD*IST used for coding and analysing data.

Results:

Leicester: 12 interviewees reported using the service for research & education. Using the critical incident technique six interviewees reported that information acquired from the service would impact on their clinical decision making. When asked how they would use the information in the future most responded for improving patient quality of life, for audits or standards of care, for patient assessment or evaluating outcomes. Research and publication were the two main reasons for obtaining information by questionnaire respondents. This reflects the opinions of research and academic staff included in the sample.

Bury St Edmunds: One question in critical incident questionnaire asking how respondents used the information they found. Most kept the information although around one third passed information to patients. Not specifically asking about the Pink Book but information in general. Interview questions about the Pink Book, how frequently people use it, awareness and positive perceptions etc do not investigate its impact, but user satisfaction.

Cornwall: Interviewees were asked about the how they put the skills learnt into practice. 19 out of 26 said they had put skills into practice 6 of these in research and education or patient management. Interviewees felt the course broadened their awareness of resources and improved searching skills.

South Humber: Interviewees reported using CINAHL for patient needs, research needs, educational needs and practice needs.

Exeter: No evidence of how the information obtained had an impact on the users' skills, knowledge or decision-making.

North Thames: Focuses on user satisfaction and where users are accessing from, not impact.

Measure of Impact: No measurable impact i.e. all qualitative and focus is on user satisfaction rather than measurable impact on their work, knowledge, skills, attitudes or decision-making. Some self-reported expected future use of information but no follow-up. Some qualitative quotes providing evidence that training sessions or resources do have an impact on user knowledge or skills

Impact not measured: The relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score.

Digital Library: Virtual Naval Hospital (VNH)

Where published: Stoloff (2001)

Description: Evaluation of a Naval Medical digital library

Setting: US Navy

Population: Military healthcare providers and other military personnel seeking healthcare information. 38% directly involved in providing patient care e.g. physician, nurse.

Methods: Two surveys, one for Military Medical Professionals (MMPs) and a second for non-medical military users. Medical users were identified by an authentication code.

Results: 462 respondents but 20% excluded as they had never used the VNH before.

Information about patient care was most sought after regardless of speciality. 70% that used the Internet version of VNH felt the available information resulted in some degree of improved care. 70% of care providers said the VNH boosted their confidence in making diagnoses and 60% in making treatment decisions.

Measure of Impact: Self-reported impact on patient care and decision-making

Impact not measured: The relationship between library features and services and the library impact and how they can be improved to increase impact; not a real-time study i.e. relies on user recall; no impact score.

The literature review did identify another digital library evaluation, that of the Alexandria Digital Library (ADL) (Borgman et al 2000; Hill et al. 2000) where the intention was to evaluate the educational impact of the ADL on student learning, however all the published research that was found described this as a future part of the project and whilst some later research has investigated user requirements by studying how users work (Borgman et al. 2004; Borgman et al 2000), there was no evidence in the research literature or on the ADL website to show if or how the impact of the ADL was evaluated. One other approach was in-class observation to investigate the effect the Perseus Digital Library had on how students approach their assignments (Yang 2001) but again, there was no indication of how service use was related to impact or how the library impact could be improved and no impact score was calculated.

In contrast to the frameworks most of the evaluations found were of medical digital libraries (Section 2.3.5). This may be due to the search strategy not identifying older non-medical evaluations published only in conference proceedings or journals not indexed in the databases searched. Although it is unlikely that huge numbers of evaluations have been missed this way as a variety of databases were searched and recent conferences and journals hand-searched (see Section 4.2). Alternatively it may be because impact evaluations in the medical digital library sector are performed more frequently because of the need to justify impact and the consequence on patient care. "Academic libraries may be more concerned with performance and usage statistics" due to the nature of their user base, for who impact is a less obvious

outcome than in the medical domain, and justification to committees for continued funding based on library usage statistics rather than impact.

2.3.6 Impact measured in previous studies

Table 2.3.6 compares the impacts measured across studies. The impacts were as follows:

- **Actual recorded impacts (i.e. not just self-reported impacts)** - two of the studies showed actual impacts with the OLEH study reporting an improvement in the correct responses to vignette style clinical scenarios (Berkenstadt et al. 2006) and the Perseus study (Marchionini & Crane 1999) showing that students who used the Perseus digital library cited a higher number of unique citations on average than those who didn't use it. These were the only two studies not to rely on self-reported recall of impacts.
- **Changes in practice or decisions** - seven of the studies report a change or improvement in an action or decision in their work (Bennett et al 2007;Crowley et al. 2003; Freeth et al. 2001;Gosling et al 2004;Nankivell et al. 2001;Richwine & McGowan 2001;Stoloff 2001;Westbrook et al 2007) ranging from 75% (Richwine & McGowan 2001) to 16% (Freeth et al 2001) of respondents reporting a change. As these are all medical digital libraries these are reported as improvements or changes in patient care or clinical practice.
- **Provide information to pass on** - two studies report that one impact of using the digital library for 68% (Sidlofsky et al 2002) and 12% (Yeoman et al 2004) of respondents respectively was to provide information to pass on to others, specifically in these cases, their patients.
- **Confirmation of a planned decision or action** - two studies report that information from the digital library was used to confirm a decision or what they were doing already in 53% of visits (Crowley et al 2003) and for 15% of respondents (Bennett et al 2007).
- **Confirmation of knowledge** – one study reported that for 26% of respondents using the Cochrane digital library confirmed their existing beliefs (Forbes et al 2007).
- **Change or improvement in knowledge** – four studies reported an improvement or change in knowledge as a result of using the digital library for 33% of respondents (Bennett et al 2007), 57.5% of interviewees (Forbes et al 2007), in 11 of 12 vignette scenarios (Berkenstadt et al 2006), and for 35% of respondents (Yeoman et al 2004).
- **General help or positive impact (no percentages)** – two studies report that users felt the digital library was of help or improved practice (Cohn et al 2003;Marchionini & Crane 1999) without providing any percentages or numbers of respondents/interviewees who reported this.
- **General help or had an impact (no detail)** – three studies provide evidence to show that users felt the library was of benefit and had an impact on their work without

specifying what this impact was and whether it changed or confirmed actions or decisions or knowledge (Brown et al 2007;Forbes et al 2007;Yeoman et al 2004).

- **Future impact** – one study reported that 17% of interviewees expected the digital library to have an impact on their decision-making in the future (Yeoman et al 2001).
- **Saved time** – one study attempted to quantify the time saved by the digital library by estimating the time it would take users to find the information they were seeking if the library had not been available (utility time) and calculated this to be the equivalent of 736 full-time researchers for a 12 month period (Accomazzi et al 2005).

It is clear there have been a variety of “impacts” measured in previous work, the next table (Table 2.3.6) shows each study and the impact it reports. However as discussed in the next section previous work falls short of meeting the requirements for digital library impact evaluation (from section 2.3.4) identified as a result of the literature review and further work is required.

Project	Study Dates	Impact Measured
CAR (Crowley et al 2003)	July 2000 – April 2001	53% of cases confirmed patient care decisions 47% changed patient management
CIAP (Gosling et al 2004) (Westbrook et al 2007)	2002-2004	35% reported direct experience of its use improving patient care 27% of all incidents resulted in measurable improvements in patient care
CLINT (Nankivell et al 2001)	December 1996 – October 1997	29% of interviewees reported making different decisions as a result of accessing CLINT
Cochrane (Forbes et al 2007)	October 2004 – December 2006	57.5% claimed to have learned something from the library 32.6% reported that it helped decision making 26.11% said it confirmed their existing beliefs

Project	Study Dates	Impact Measured
Federal eLibrary (Brown et al 2007)	November 2005 – January 2006	80% felt the impact of access to the library on their research and productivity was positive or very positive
Forest Healthcare Trust (Freeth et al 2001)	1999	16% identified 11 examples of changed practice
MDConsult (Cohn et al 2003)	Not specified but published in 2003	No figures given but overall most agreed it improved patient care decisions
NASA ADS (Accomazzi et al 2005)	2002	Saved time equivalent to 736 full-time researchers
OLEH (Berkenstadt et al 2006)	Not specified but published in 2006	In 11 of 12 scenarios the OLEH was associated with higher scores and in 10 scenarios with decreased critical errors

Project	Study Dates	Impact Measured
OTSeeker (Bennett et al 2007)	December 2004 – January 2005	19% reported changes in practice 38% reported an improvement in knowledge 15% confirmed what they were doing
Perseus (Marchionini & Crane 1999)	1989-1992	Mean number of citations in coursework for students who used Perseus was 18.6 compared with 9.4 for those who didn't use Perseus.
SHELSI (Richwine & McGowan 2001a)	1999	75% said information obtained enabled them to handle a clinical situation differently with the degree of importance of this change averaging 7 out of 10
SWICE (Yeoman et al 2004)	2003	32.1% reported to use the resource for direct patient care 51.4% used it for CPD 34.9% used it to add to their general knowledge 11.9% used it to pass information found onto a patient

Project	Study Dates	Impact Measured
Toronto UHN Virtual Library (Sidlofsky et al 2002)	Mid-June 2001 to mid-July 2001	68% reported the resource influenced overall advice given to patients
VIVOS (Yeoman et al 2001)	2000-2001	17% of interviewees reported that information acquired from the service would impact on their clinical decision making
VNH (Stoloff 2001)	February 2000 – August 2000	70% reported some degree of improvement in patient care

Table 2.3.6 Impact measured by previous studies

2.3.7 Impact not measured in previous studies

Clearly users of digital libraries believe they are having an impact on their work and knowledge, however there is little attempt to quantify the impact by evaluators and researchers. The attempt to do so by the NASA ADS evaluation is perhaps an over estimate as the authors assume a set time (15 minutes) it would take to retrieve a full-text article by visiting a physical library and multiply this by the number of full-text article downloads. This doesn't take into account that a researcher may wait and retrieve several articles at once from one visit to a physical library rather than visiting each time a need for an article arises. Nevertheless this digital library would appear to have a huge impact on the amount of time it takes for researchers in this field to keep up with the literature and retrieve articles. This is however a specialised field where it is possible comparative resources do not exist and the information required is not publically available. Therefore the benefit of the library will be greater and easier to measure in this way than for a medical digital library where several similar resources are available or even Internet search engines that may retrieve potentially relevant material. This would make estimating the amount of time it would take to find a resource without using the library much more difficult. But how well do previous studies measure up to the requirements set out for an ideal digital library evaluation in Section 2.3.4. Table 2.3.7 shows where each evaluation fails to meet one or more requirements. Most studies met the first three requirements and all but one of these (the NASA ADS evaluation (Accomazzi et al 2005) met at least one of these three. However, none of the evaluations made any attempt to identify the relationship between library features and services and impact; only two measured real-time use i.e. impact at the actual point of use not previous use as recalled by the user; and only one attempted to quantify the impact. This was the NASA ADS evaluation which produced a utility time value as discussed above. The problem with this measure of impact is that no information is available about how the library is used, what changes occur as a result of use or what services can be improved to improve impact. It is a somewhat arbitrary measure that is detached from the real-world setting of the library users, however could be used to provide economic justification for a digital library compared to a physical library.

	CIAP	CLINT	Cochrane	CAR	Fed e-Sci	Forest	MDCConsult	NASA ADS	OLEH	OTSeeker	Perseus	SHELSI	SWICE	Toronto	VIVOS	Stoloff
I. Identify the effect or impression of the digital library on the user and their work	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
II. Identify the short and long-term changes the library makes to the user and their work	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
III. Identify how the library is being used to help the user in their work	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IV. Identify the relationship between library features and services and the library impact and how they can be improved to increase impact	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
V. Measure real-time use	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No	No	No	No
VI. Measure real-world use	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VII. Evaluate real users	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VIII. Produce a quantifiable impact score	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No	No	No	No

Table 2.3.7 Digital library impact evaluation requirements not met by previous evaluations

Other than the NASA ADS evaluation the only other study to report the impact of real-time use of a digital library is the CAR evaluation (Crowley et al 2003). It seems that digital library impact evaluation so far has rarely been formative with no evaluation in Section 3.3.5 identifying how different library features and services affect the impact of the library and how they can be improved to increase its impact. This is key to ensure that digital libraries, which are constantly evolving entities changing as technologies improve and content is developed, consistently have an impact and are able to improve that impact over time. The next section discusses the methods used in these impact evaluations and their strengths and weaknesses.

2.4 Review of Data Collection Methods

In order to collect data that will show the impact of a digital library, appropriate methods must be chosen for the model and framework. Three main methods of data collection have been used in the digital library impact evaluation studies reviewed in Section 2.3.5, questionnaires, web server logs and interviews. These three methods and their benefits and pitfalls are discussed below.

2.4.1 Questionnaires

Questionnaires are a commonly used tool for collecting large amounts of data, particularly in the library setting (Adams & Cox 2008; Crawford 2000). Questionnaires can be used effectively to collect large amounts of data quickly without burdening the respondent with in-depth questions (Bell 1999; Crawford 2000). However, whilst useful, particularly in this research where respondents are likely to face time constraints, questionnaires must be well designed to collect useful data and ideally supported by more qualitative research which can bridge the gap between a respondent's answer and their attitude and subsequent behaviour (Williams & Gunter 2006). In the evaluations identified in Section 2.3.5 questionnaires were used for the following purposes to evaluate impact:

- To identify the specific resources or services within the digital library that users report using (Bennett et al 2007; Freeth et al 2001; Gosling et al 2004; Marchionini & Crane 1999; Richwine & McGowan 2001; Sidlofsky et al 2002; Stolloff 2001; Westbrook et al 2007; Yeoman et al 2001; Yeoman et al 2004)

- To allow users to select from a multiple choice of reasons for accessing the digital library and the intended use of the information sought (Bennett et al 2007;Brown et al 2007;Cohn et al 2003;Crowley et al 2003;Freeth et al 2001;Gosling et al 2004;Richwine & McGowan 2001;Stoloff 2001;Westbrook et al 2007;Yeoman et al 2001;Yeoman et al 2004)
- To allow users to indicate whether the digital library had a positive impact on their work and in what ways (Bennett et al 2007;Brown et al 2007;Cohn et al 2003;Crowley et al 2003;Freeth et al 2001;Gosling et al 2004;Marchionini & Crane 1999;Richwine & McGowan 2001;Sidlofsky et al 2002;Stoloff 2001;Westbrook et al 2007;Yeoman et al 2001;Yeoman et al 2004)
- To test actual knowledge changes in a clinical scenario as a result of using the digital library (Birkenstadt et al 2006)
- To investigate the factors that support or hinder use of the library (Bennett et al 2007;Brown et al 2007;Freeth et al 2001;Gosling et al 2004;Marchionini & Crane 1999;Sidlofsky et al 2002;Stoloff 2001;Westbrook et al 2007;Yeoman et al 2001;Yeoman et al 2004)

Clearly questionnaires are a popular method of collecting data in digital library evaluations and can provide useful information to indicate how a library is being used. However, often questionnaires use short, closed or multiple choice questions with little encouragement for users to include a detailed qualitative response. Therefore whilst useful, the information obtained by these questionnaires is limited and should be supported by other methods such as web server logs and interviews.

2.4.2 Web server log analysis

Web server logs are simply records of transactions of activity on a website. Web servers record this information automatically without any effort required on the part of the website user. This is a cheap method of data collection as the log data is often freely available to website administrators. We can find general patterns in use e.g. most commonly visited pages, search terms used, time spent on a page etc as well as employ a technique known as microanalysis, analysing use of the library by a small number of individual users (Nicholas et al 2003). This provides a clearer picture of individual user behaviour when in the library, rather than just general trends. Logs are collected without users' knowledge, therefore are less open to bias. The access logs provide quantitative data about users in the following fields: The IP or hostname of the origin of the request; date and time of the request the type of request; the page requested; the returned status of the page; and the number of bytes transferred. In addition, other fields can be specified such as the referring page enabling identification of where users come to the digital library from. There are inconsistencies in log data e.g. when users click on

the back button of their browser this is not recorded therefore the web log data can make it look like a user has jumped between unconnected pages, however using the referring page field it can be possible to “fill in the gaps”. Web logs provide information on how users are actually navigating through the library not just how they tell you they navigate. Research has shown that reported use and actual use differs substantially, perhaps due to misunderstanding or simply users trying to answer questions with what they see as the “correct” answer (Roy 2004). However, caution should be exercised when using web log data alone as no information is provided about the user (unless the user is registered with the library and has previously provided personal data). In addition it can be difficult to identify separate visits from gateway users such as NHS staff who may access at the same time from the same IP address despite being on different computers and no inference can be drawn from what is observed. For example if a user has a gap of 25 minutes within a visit to the library there is no way of knowing if this is because they are reading a library document, because they are doing something else on their computer or because they have simply had a break or been distracted by someone or something. That said, as a complementary method web log analysis provides much valuable information about how users are navigating a website and limited data about where users are accessing from. So when combined with data from other sources it can help identify patterns of use that would not otherwise be seen. Web transaction logs were used in the evaluations discussed in Section 2.3.5 to support impact evaluation as follows:

- To identify specific resources and services that are actually used by library users (Accomazzi et al 2005; Brown et al 2007; Crowley et al 2003; Forbes et al 2007; Gosling et al 2004; Nankivell et al 2001; Westbrook et al 2007)
- To identify basic visitor statistics for use of the digital library (Accomazzi et al 2005; Brown et al 2007; Cohn et al 2003; Crowley et al 2003; Forbes et al 2007; Gosling et al 2004; Nankivell et al 2001; Sidlofsky et al 2002; Westbrook et al 2007)
- To identify navigation strategies e.g. searching and browsing patterns (Brown et al 2007; Forbes et al 2007; Gosling et al 2004; Nankivell et al 2001; Westbrook et al 2007)

In these studies weblogs are used as supporting evidence to provide information about how the digital library is actually used compared with how users report using it in questionnaire and interview responses. Only one study (Westbrook et al 2007) actually used the weblog data as a comparison of how users reported their activity and this was just to compare reports of the types of resources within the library that users accessed. They found that reported and actual use were comparable.

2.4.3 Interviews

Interviews are a method of obtaining qualitative data to either support questionnaire development, explore issues identified by questionnaires in more depth or as a stand-alone

method (Bell 1999; Moore 2000). They can range from structured where the format is more like a questionnaire that is filled in by the interviewer rather than the interviewee, to semi-structured or unstructured where the interviewer is guided by the interviewee. The more structured the interview the easier the data is to analyse but the less likely the interviewee will feel comfortable enough to explore issues in depth. However, unstructured interviews require great skill on the part of the interviewer to extract the relevant information from interviewees without enforcing a structure on the interview (Adams & Cox 2008; Bell 1999). Semi-structured interviews can allow use of a flexible structure that provides the interviewer with a way of ensuring relevant topics are discussed without making the interviewee feel uncomfortable or restricted (Adams & Cox 2008; Bell 1999; Williams & Gunter 2006). Interviews have been used in the evaluation studies presented in Section 2.3.5 to support impact evaluation in the following ways:

- To identify and/or discuss specific resources and services the user reports using (Forbes et al 2007; Marchionini & Crane 1999; Nankivell et al 2001; Westbrook et al 2007; Yeoman et al 2001; Yeoman et al 2004)
- To identify and/or discuss reasons for use and intended use of the information sought (Forbes et al 2007; Marchionini & Crane 1999; Nankivell et al 2001; Westbrook et al 2007; Yeoman 2001; Yeoman 2004)
- To identify and/or discuss where the digital library has had a positive impact on the user's work (Marchionini & Crane 1999; Westbrook et al 2007; Yeoman et al 2001; Yeoman et al 2004)
- By using the critical incident technique to explore how the user has used the digital library in a work situation (Westbrook et al 2007; Yeoman et al 2001)
- To identify and/or discuss the factors that support or hinder use of the digital library and its impact (Marchionini & Crane 1999; Nankivell et al 2001; Westbrook et al 2007; Yeoman et al 2001; Yeoman et al 2004)

One of the studies (Forbes et al 2007) used telephone interviews as its only method of data collection and this took the form of a very structured questionnaire type interview where interviewees were asked specific, often closed questions with little opportunity to expand on what was said. Another study (Richwine & McGowan 2001) used interviews to complement questionnaires but did not use them to collect information about the impact of the library but to assess attitudes to the importance of having access to electronic information. Where detail was provided in the literature it was clear that most of the interviews used in the remaining evaluations were face-to-face semi-structured interviews where a list of topics or questions to be discussed was used but where interviewees were able to expand on these and encouraged to provide detailed examples. Two of the studies used the critical incident technique where interviewees were asked to recall a specific incident where they used the library and to describe why and how they used it and the impact it had on their work (Westbrook et al 2007; Yeoman et al 2001).

2.4.4 Summary of impact evaluation methods

Three methods of data collection used in previous impact evaluation studies have been presented and discussed. The following chapter discusses how data collection from these three different methods will be linked together on an individual user basis, something that has not been done in previous work. There are, of course, many other research methods available such as focus groups and empirical studies. However, the former more qualitative approaches do not fit with the objectives of the research framework as they are not easy to conduct with unknown geographically dispersed users. Empirical studies are also not appropriate for this digital library impact evaluation framework for the same reasons, as actual measures such as antibiotic prescribing rates or alcohol gel usage cannot be recorded at the place of the users' work. Online focus groups are a potential development for future research but may be biased towards users who are experience Internet users. Observational studies are also a valid research method but the web server log data collection is a form of observational study that is much easier to conduct in conjunction with questionnaire data and interviews to provide qualitative support. The next section summarises the limitations of the previous work and presents a set of criteria for the evaluation framework based on previous evaluations but adapted to meet the ideal digital library impact evaluation requirements (Section 2.3.4).

2.5 Discussion

2.5.1 Limitations of current approaches to digital library impact evaluation

It is clear from both reviews of current available frameworks and measures (Table 2.3.2) and the current state of research described in Sections 2.3.5 and 2.4 that digital library impact evaluation research is lacking in both the availability of frameworks and measures and in current research. Thirteen of the evaluation studies measured impact in terms of self-reported changes in decision-making both retrospective and prospective either by multiple choice questions with or without comments or by interviews (Bennett et al 2007; Brown et al 2007; Cohn et al 2003; Crowley et al 2003; Forbes et al 2007; Freeth et al 2001; Gosling et al 2004; Nankivell et al 2001; Richwine & McGowan 2001; Sidlofsky et al 2002; Stoloff 2001; Westbrook et al 2007; Yeoman et al 2001; Yeoman et al 2004). The OLEH evaluation (Berkenstadt et al 2006) measured impact in terms of influence of the digital library on clinical decision-making in a scenario presented to the participant. The NASA ADS evaluation (Accomazzi et al 2005) measured impact in terms of utility time i.e. time saved. Whilst retrospectively self-reported changes in decision-making and the impact of a digital library on decision-making in a scenario are both valid methods of impact measurement, neither are sufficient alone to determine the impact of a digital library on its users. The former is relying on users either remembering whether the digital library influenced their decision or reporting their expectations for the impact

of the digital library in the future. Both of these may result in a more positive rather than accurate result as users overestimate the future impact of the digital library or report on a single incident (not necessarily a typical incident) of digital library use where the digital library had an impact on their decision-making. The measure of changes in decision-making with use of a digital library using a clinical scenario is an indicator of whether the digital library has the potential to aid decision-making in clinical practice but cannot be wholly representative of this as it is not subject to the constraints that may be present in the environment in which the user may be accessing the digital library from in the real-world e.g. busy hospital ward or GP surgery.

2.5.2 Criteria for a digital library impact evaluation

So what are the criteria for a comprehensive digital library impact evaluation that fulfil the requirements described in Section 2.3.4? In order to ensure comprehensiveness by taking into account the different approaches used by different studies to impact evaluation, criteria used by all the studies in Section 2.3.5 were identified and sorted into the four dimensions of digital library work presented in Section 2.2.2 (Community, Services, Technology and Content). A single list was then created by removing overlapping criteria. These were then mapped against the requirements for digital library impact evaluation (Section 2.3.4) to ensure all requirements were met. A digital library impact evaluation should therefore investigate the following:

1. Community:

- 1.1. How the digital library is used in the work setting and what are the reasons for use (Brown et al 2007;Cohn et al 2003;Gosling et al 2004;Marchionini & Crane 1999;Nankivell et al 2001;Richwine & McGowan 2001a;Stoloff 2001;Westbrook et al 2007;Yeoman et al 2001;Yeoman et al) *Helps meet requirement III.*
- 1.2. The suitability of the work environment for integrating the digital library into work practice e.g. access to the Internet (Bennett et al 2007;Berkenstadt et al 2006;Freeth et al 2001;Gosling et al 2004;Marchionini & Crane 1999;Richwine & McGowan 2001;Stoloff 2001;Westbrook et al 2007;Yeoman et al 2004) *Helps meet requirement III.*
- 1.3. Acceptability of the digital library by employers/colleagues i.e. support given for using the digital library in work time & space (Gosling et al 2004;Marchionini & Crane 1999;Westbrook et al 2007) *Helps meet requirement III.*
- 1.4. Awareness of the digital library in the target community, not just those who use it already (Gosling et al 2004;Westbrook et al 2007;Yeoman et al 2001) *Helps meet requirement I.*
- 1.5. Basic demographic information of users (Accomazzi et al 2005;Bennett et al 2007;Berkenstadt et al 2006;Cohn et al 2003;Crowley et al 2003;Forbes et al 2007;Freeth et al 2001;Gosling et al 2004;Richwine & McGowan 2001;Sidlofsky et al

2002;Stoloff 2001;Westbrook et al 2007;Yeoman et al 2001;Yeoman et al 2004) *Helps meet requirement VII.*

2. Services:

- 2.1. User satisfaction with the digital library & how it meets user needs (Bennett et al 2007;Berkenstadt et al 2006;Brown et al 2007;Cohn et al 2003;Forbes et al 2007;Freeth et al 2001;Gosling et al 2004;Marchionini & Crane 1999;Nankivell et al 2001;Stoloff 2001;Westbrook et al 2007;Yeoman et al 2001;Yeoman et al 2004) *Helps meet requirement I.*
- 2.2. Preferred resources/services already offered by the digital library (Brown et al 2007;Cohn et al 2003;Crowley et al 2003;Gosling et al 2004;Marchionini & Crane 1999;Nankivell et al 2001;Richwine & McGowan 2001;Sidlofsky et al 2002;Westbrook et al 2007;Yeoman et al 2001;Yeoman et al 2004) *Helps meet requirements I & IV*
- 2.3. Gaps in provision (Marchionini & Crane 1999;Stoloff 2001) *Helps meet requirements I & IV*
- 2.4. Awareness of current digital library services and content to existing users (Forbes et al 2007;Marchionini & Crane 1999;Yeoman et al 2004) *Helps meet requirement IV*

3. Technology:

- 3.1. Basic web access log statistics to see frequency of use and patterns of use (Accomazzi et al 2005;Brown et al 2007;Cohn et al 2003;Crowley et al 2003b;Forbes et al 2007;Freeth et al 2001;Nankivell et al 2001;Sidlofsky et al 2002;Westbrook et al 2007;Yeoman et al 2004) *Helps meet requirement IV.*
- 3.2. Usability of the digital library (Berkenstadt et al 2006;Freeth et al 2001;Gosling et al 2004;Marchionini & Crane 1999;Nankivell et al 2001;Sidlofsky et al 2002;Stoloff 2001;Westbrook et al 2007;Yeoman et al 2004) *Helps meet requirement I.*
- 3.3. Search query analysis i.e. how are people searching the digital library, for what topics/parameters and are they finding what they are looking for (Nankivell et al 2001) *Helps meet requirement IV.*
- 3.4. Navigation pathway analysis to identify how users are navigating the digital library and what services are commonly used (Marchionini & Crane 1999) *Helps meet requirement IV.*

4. Content:

- 4.1. Knowledge and attitude changes as a result of using the digital library e.g. actual or self-reported (Forbes et al 2007;Gosling et al 2004;Westbrook et al 2007;Yeoman et al 2004) recorded at the time of library use. *Helps meet requirements II & V.*
- 4.2. The impact of using the digital library on user work in a real-world setting e.g. clinical decision-making and patient care, use in creating documents such as policies, guidelines or coursework (Accomazzi et al 2005;Bennett et al 2007;Brown et al 2007;Cohn et al 2003;Crowley et al 2003;Forbes et al 2007;Freeth et al 2001;Gosling et al 2004;Marchionini & Crane 1999;Nankivell et al 2001;Richwine & McGowan

2001;Sidlofsky et al 2002;Stoloff 2001;Westbrook et al 2007;Yeoman et al 2001;Yeoman et al 2004) *Helps meet requirements III & VI.*

4.3. The dissemination of information found in the digital library to others (Gosling et al 2004;Westbrook et al 2007;Yeoman et al 2004) *Helps meet requirement III.*

This list reflects not only the impact on the user but also the factors that can be investigated to identify how impact may be improved and what influences the impact. That is does support from a users' employer to use digital libraries influence the impact the library has on their work? Or does the navigation strategy users select have an influence? These and other questions based on the criteria above are all important for formative evaluation where the aim is to improve the digital library as a result of the evaluation not just evaluate how well it performs.

2.6 Summary

This chapter has discussed digital library definitions and dimensions and reviewed the current state of research in digital library impact evaluation. It has identified a need for further research that develops a model or framework to evaluate the impact of a digital library on user work and the factors that influence this impact to enable improvements to be made to the library. The key findings of this chapter are:

- Any proposed model for digital library impact evaluation will have to take into account the interactions between the four dimensions of digital library work (community, services, technology and content)
- No real attention is given in any of the existing frameworks to include generic criteria to investigate the impact of the digital library on end users' work.
- Three main methods of data collection have been used in previous digital library impact evaluation studies; questionnaires, web transaction logs and interviews.
- Users of digital libraries believe they are having an impact on their work and knowledge, however there is little attempt to quantify the impact by evaluators and researchers and no attempt to identify how different services or features of the library are related to impact.
- Therefore there is a gap in the current state of the art for a framework or model for digital library impact evaluation that not only evaluates the impact a digital library has on user work but also the factors that influence this.

The next chapter proposes a new approach to digital library evaluation to fit this gap. The research aims to develop a more inclusive approach to digital library evaluation evaluating the

impact of digital libraries on user knowledge and attitude, and work as well as investigating in more depth how features and use of the digital library relate to its impact.

Chapter 3 - A New Model of Digital Library Impact Evaluation

3.1 Introduction

This section presents an alternative approach to digital library impact evaluation based on evaluating knowledge and attitude changes of users at the point of use in a real world situation. Ideally we would be able to observe directly the effects of a digital library on a users' work, however in reality this is not a practical activity for most digital library providers. When your users are geographically diverse and anonymous it is impossible to see this impact first-hand. There is an alternative however, that is to measure knowledge and attitude changes of users. Not by asking them to recall if the library has ever had an impact on their knowledge or their work as has been for most of the evaluations discussed in Section 2.3.4 but by actually measuring their specific knowledge and attitude changes at the point of use in real-time. This approach has been piloted with a small digital library in the healthcare domain where library users were asked a series of questions before using the library and then asked the same questions after using the library showing positive changes in knowledge and attitude (Madle et al 2003; Madle et al 2004). However this pilot was very specific to the subject matter of the library and was not performed in real world settings so users were not visiting with their own information need. A new approach is required that enables a framework to be developed that can evaluate their knowledge and attitude change regardless of their information need or whether they are in academia, business or a clinical healthcare setting. This chapter presents such an approach, firstly by defining knowledge and attitude and justifying how they can be used as measures of impact by being indicators of behaviour. It then discusses methods of measuring changes in knowledge and attitude and finally presents a new model and framework for digital library impact evaluation to meet the requirements previously identified.

3.2 Defining knowledge

Understanding what knowledge is and means is no easy task. Indeed a whole branch of philosophy "Epistemology" has been dedicated to the study of the theory of knowledge. The aim of this section is purely to present a summary of how current thinking about knowledge can relate to digital library impact evaluation, not to present the theory of knowledge. Most theorists now agree that knowledge is "true belief" although there is some debate remaining about whether this should be justified (Goldman 2005). There are many definitions of knowledge but it is suggested there are two main types of knowledge (Lowe 2005):

- Knowledge that is known through experience (*a posteriori*)

- Knowledge that is known independent of experience (*a priori*)

Gaining knowledge through a resource such as a healthcare digital library could be considered *a priori* knowledge if the user is learning from guidelines and protocols written by other people. For example, a health professional faced with managing an outbreak of *clostridium difficile* in a ward may find a document reporting best practice. They may have no experience of this but are able to gain knowledge by learning about other health professionals' experience, which has been analysed and summarised in the document.

One Oxford Online Dictionary definition of knowledge is:

"facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject" (Goldberg 2005)

It is clear here that there is a link between knowledge and information and the distinction between the two has been the subject of much discussion in the information science domain. The data, information, knowledge, wisdom (DIKW) pyramid is a hierarchy that has resulted from the T.S. Eliot poem "The Rock" (Cleveland 1982):

Where is the life we have lost in living?

Where is the wisdom we have lost in knowledge?

Where is the knowledge we have lost in information?

In possibly the earliest application of this poem to the Information Science domain Cleveland (1982) suggests that knowledge is a refined form of information, where information is organised to be useful. He goes on to say that most knowledge is expertness and wisdom is integrated knowledge i.e. where links are made between separate knowledge. In a review of representations of the DIKW pyramid in information and knowledge management textbooks Jennifer Rowley (2007) reports that definitions of knowledge tend to include reference to information, either discussing the process of converting information to knowledge or the added ingredients that make knowledge, knowledge, rather than just information. In contrast to the DIKW hierarchical approach, in a medical informatics textbook Coiera (1997) presents a cyclical approach where knowledge is applied to derive meaning from data (i.e.create information)

which in turn gives new knowledge. The hierarchical approach requires the library to organise information so it can be found by the user to help gain knowledge whilst the cyclical approach suggests the user plays a more active role in gaining new knowledge by applying their existing knowledge.

In this research the key question to be answered about knowledge is whether digital library users can use the library to gain knowledge from the information stored in the library documents. Regardless of which approach to describing the relationships between knowledge and information you prefer a library needs to enable its users to access either data or information to result in a gain in knowledge. This sharing of what is termed “explicit knowledge” (i.e. knowledge that can be written down) (Rowley 2007) could be considered a fundamental aim of digital libraries, in order for them to equip users with the knowledge necessary to carry out their work, whether that be appropriate clinical guidelines, relevant articles for an assignment or evidence to support decision-making.

3.3 Defining attitude

Attitude research has also attracted significant amounts of attention from the academic world and key psychologists Fishbein and Ajzen suggest that:

“Attitude refers to a person’s favourable or unfavourable evaluation of an object, event or person” (Fishbein & Ajzen 1975)

Later in his Theory of Planned Behaviour, Ajzen defines attitude toward a behaviour as:

“...the degree to which performance of the behavior is positively or negatively valued” (Ajzen 2006)

The Oxford Dictionary of Philosophy states that attitude is an evaluative response (Blackburn 1996) and Eagly & Chaiken report it to be:

"a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour." (Eagly & Chaiken 1993)

It is clear from these definitions that there is general consensus on the definition of attitude, that it involves placing value or judgement on something or someone. In a digital library context attitudes are important as the value or judgement a healthcare professional places on the information held within the library may affect the impact this information has on their work (Fishbein & Ajzen 1975).

3.4 The Theory of Planned Behaviour

So now we have defined knowledge and attitude but are they important as indicators of behaviour? Is there any point measuring them in place of actual behaviour? How often does what we know and think about something influence what we do? Is the knowledge people gain from a digital library likely to have an impact on their behaviour? The use of measuring attitudes to predict behaviour is a widely debated topic in social psychology. There are many models that attempt to explain what factors influence behaviour and the cognitive processes that underly implementation of specific behaviours. A key general model is the Theory of Planned Behaviour. Ajzen developed the Theory of Planned Behaviour (Ajzen 1991) as an extension to the Theory of Reasoned Action proposed jointly with Fishbein (Ajzen & Fishbein 1980). The Theory of Reasoned Action states that if people evaluate a certain behaviour as positive and believe others (who are important to them in this instance) want them to perform the behaviour then they have a motivation or intention to do so and are more likely to perform the behaviour. However, this theory does not take into account the circumstances that may prevent someone from undertaking the intended behaviour and Ajzen therefore added "perceived behavioural control" as a component and created the Theory of Planned Behaviour.

The theory is presented as a diagram in Figure 3.4 using an example of a clinician using a digital library to search for information to help make a decision about prescribing antibiotics for a patient with acute otitis media. Acute otitis media is a common childhood ear infection and the evidence for prescribing antibiotics is not straightforward with one study suggesting that 17 children would need to be prescribed antibiotics for just one to benefit (Glasziou et al. 2004). Prescribing for such an infection requires a clinician to balance the potential benefit to their patient with the potential risk of antibiotic resistance in the general population through overuse of antibiotics. In the scenario in Figure 3.4 three components influence whether or not the clinician performs a certain behaviour.

- Attitude toward the behaviour – this is influenced by his/her beliefs about the behaviour. For example does he/she believe that over-prescribing of antibiotics contributes to antibiotic resistance and therefore that prescribing antibiotics in this case when they may be unnecessary could contribute to antibiotic resistance?
- Subjective norm – what do others think about prescribing in this instance and what significance does the clinician place on their views. For example is the clinician going to feel more pressure from the patient expecting an antibiotic or from the professional bodies promoting prudent antibiotic use?
- Behavioural control – this is influenced by what the clinician believes hinders or helps him/her in carrying out the behaviour. For example short consultation times may not help the clinician avoid prescribing by limiting the time he/she has to explain the reasons to the patient, evidence found to support non-prescribing or public education materials he/she can pass on to the patient may help. Perceived behavioural control may or may not be the same as actual behavioural control depending on the clinician's perception.

The combination of all these factors will lead to the intention, in this case either to prescribe or not. Use of a digital library in this scenario could influence all three of these components:

- Attitude toward the behaviour – by providing knowledge and influencing the belief about whether or not prescribing is necessary, therefore changing the attitude towards the behaviour
- Subjective norm - by providing information about expectations of the professional community
- Behavioural control - by providing relevant evidence to show as justification for the decision made

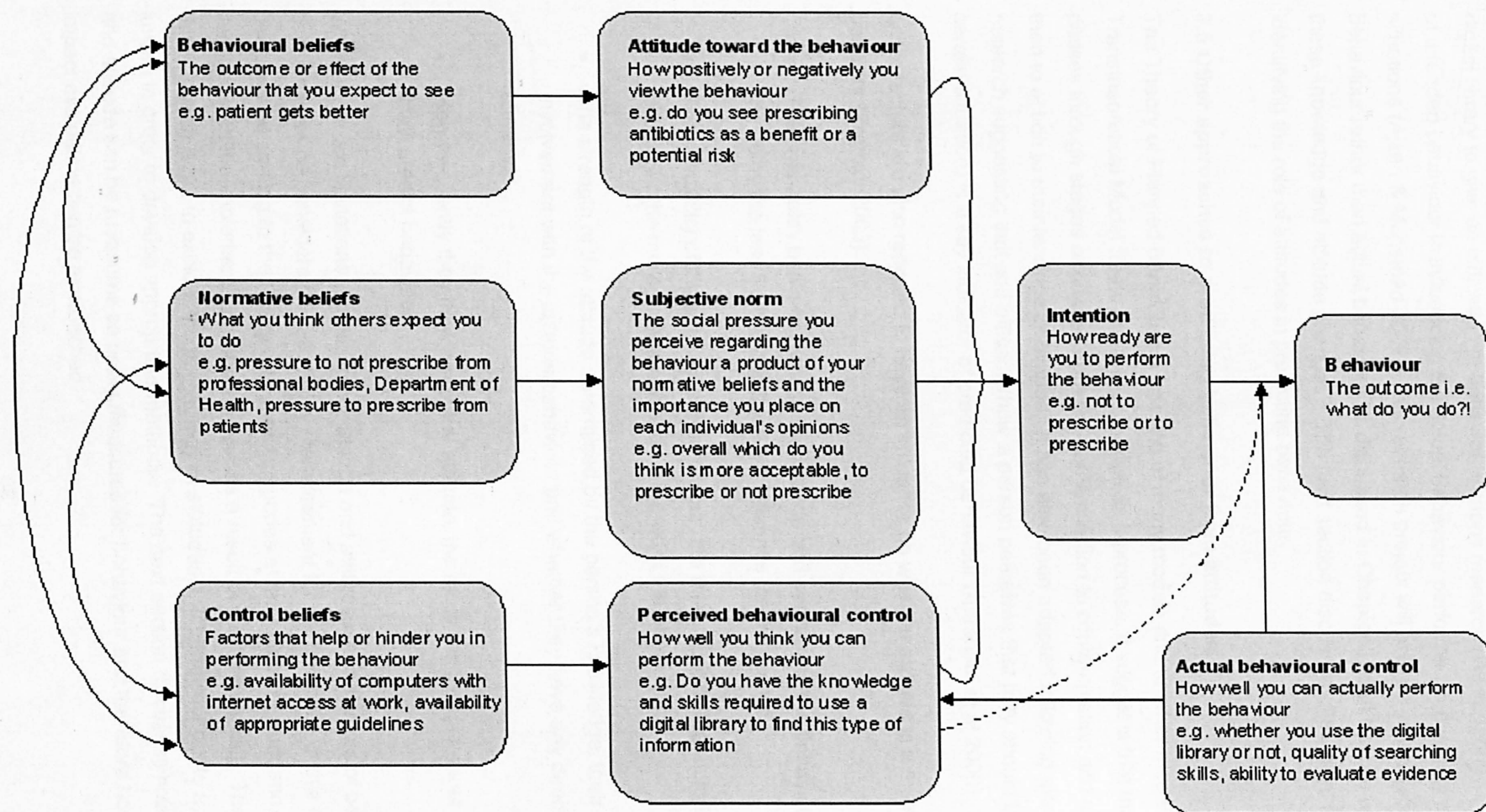


Figure 3.4 The theory of planned behaviour as applied to a clinician using a digital library to provide information for decision-making about prescribing antibiotics for a patient with acute otitis media. Adapted from (Ajzen 1991; Ajzen & Manstead 2007)

This provides justification for measuring knowledge and attitude changes following use of a digital library to give an indication of behavior. Various research has supported the importance of intended behaviour in influencing the actual behaviour performed in a variety of healthcare situations (Ajzen & Manstead 2007). This research project will only be investigating intended behaviour rather than actual behaviour as discussed in Chapter 1. But how do we measure these knowledge and attitude changes? The next section discusses alternative approaches to identifying the role of attitudes in predicting behaviour.

3.5 Other approaches to predicting behaviour from attitudes

The Theory of Planned Behaviour is just one of many models and another model the Transtheoretical Model treats behaviour change as a process. It suggests that the individual passes through stages or phases from pre-contemplation to contemplation and preparation, then to action to maintenance or relapse. It has also been adapted following more recent research suggesting that self-efficacy (how a person perceives that they should behave in a certain situation) is a key indicator of predicted behaviour (Abraham et al 2000).

Other factors are also reported to have an influence on whether attitude is a reliable predictor of behavior (Franzoi 2003):

- The time delay between forming the attitude and performing the behaviour, the longer the delay the less likely the attitude will influence the behaviour.
- The specificity of the attitude and behaviour, the more specific the attitude and behaviour the more likely the attitude will predict the behaviour.
- The strength of the attitude determined by the person's knowledge, their personal involvement with the attitude/behaviour and whether they have any direct experience already.
- How frequently they think about the attitude, the more it is thought about the more likely it will predict behaviour.

Whilst there are limitations with using knowledge and attitudes as indicators of behaviour they can therefore be considered a valid proxy measurement for the purposes of this research where users will be coming to the library with specific queries at their place of work and potentially be involved with the implementation of behaviour as a result of their library visit. The purpose of this research is not to explore the psychology of attitudes and behaviour but to apply what is known in order to develop appropriate methods. The next section discusses how knowledge and attitude can be measures as proxy measures for behaviour and therefore how digital library impact evaluation can be approached.

3.6 Measuring knowledge and attitude

The traditional approach to measuring knowledge and attitude is assessment by asking questions about topics and providing scales for attitude measurement. There are several scales for measuring attitude (Fishbein & Ajzen 1975). However, in the case of digital library impact evaluation, scale measurement or asking specific questions to which there are right and wrong answers requires pre-knowledge about what the user is visiting the library for in order to ask the appropriate questions. Obviously this will not be possible and an alternative approach has to be taken. A specific information seeking model, Dervin's Sense-Making approach, can help to provide this alternative approach as discussed below.

3.6.1 Dervin's sense-making approach

A model or framework can be a useful tool for developing methodologies. Most information seeking behaviour models describe the stages of an information seeking activity and its causes and consequences (Wilson 1999). Wilson (1999) reviews four key information behaviour models:

- Wilson 1981 & Wilson 1996 – the latter is a revision of the earlier model. This model describes where information needs arise and what prevents information seeking
- Ellis 1989 – describes the process of information seeking
- Kuhlthau 1991 – describes feelings thoughts and actions during the information seeking process
- Dervin 1983 – how do people bridge the gap between the situation and the outcome

Wilson's model explores the "what" of information seeking, what are the information needs, what causes them, what prevents them being satisfied. Ellis and Kuhlthau describe processes and feelings of the users. In contrast Dervin's approach is, as Wilson describes

"a model of methodology, rather than a model of a set of activities or a situation" (Wilson 1999).

Dervin's approach allows exploration of "how" users meet their information need and the impact on the user of the information seeking behaviour. The "how" of information seeking. The model is shown in figure 3.6.1.

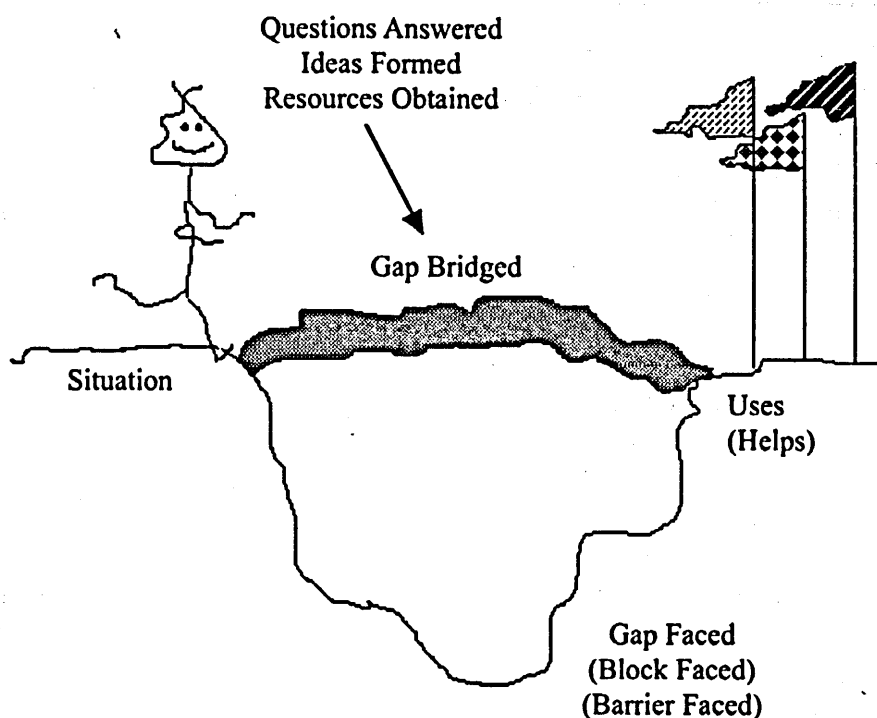


Figure 3.5.1 Dervin's Sense-Making model (taken from (Dervin 2003b))

Applying the scenario used in the previous section of a clinician requiring information about antibiotic prescribing in acute otitis media, the path from situation to outcome could be as follows:

- Situation – patient with acute otitis media, do they require antibiotics or not?
- Gap faced – clinician unsure of whether antibiotics are necessary, requires evidence on which to base a decision
- Gap bridged – digital library provides evidence, adds to clinician's knowledge, perhaps changes attitude to prescribing
- Outcome – patient is or is not prescribed antibiotics

This simple scenario illustrates how a gap can be bridged by use of a digital library and how knowledge and attitudes can be involved.

Dervin has developed a sense-making methodology from this model (Dervin 2003a; Dervin 2003b; Dervin 1997) that has been used in over 40 studies (Dervin 2003b). The benefit of this

approach to this research is the ability to extract information from users about the impact of the information contained within the digital library on their knowledge and attitudes and intended behaviour. However the methodology itself is rather complicated and a full critique and application is unnecessary for the purposes of this research. Here the sense-making model (Figure 3.6.1) is being applied rather than the sense-making methodology being used. What is important is to use the model to help in identifying how users build their bridge using the digital library. This can be done by adapting sample instruments from Brenda Dervin's home page (Cheuk Wai-Yi 2002;Dervin 1997;Rajendram 1997) as required. It should be noted that the sense-making approach is being used in this research to support impact evaluation by providing techniques to be adopted in the methods of the evaluation model and that this is not a research project about sense-making per se. Using the sense-making approach to inform questionnaire design will result in questionnaires that investigate how the user tries to build a bridge over their information gap by using the digital library and how this applies to their situation rather than just asking them factual or Likert scale questions. The response will therefore be more qualitative than quantitative.

3.6.2 Arguments for and against measuring knowledge and attitude changes

There are clear benefits to using knowledge and attitude changes as measures of impact:

- They are relatively easy to measure and analyse. Questionnaires can be used to collect data that shows changes in knowledge and attitude (Madle et al 2003). As discussed in the previous chapter (Section 2.4.1) these are an easy way of collecting large amounts of data, particularly quantitative data from multiple choice or Likert scale questions. However, the application of the sense-making approach will result in more qualitative data which does make analysis a more complicated process as themes have to be drawn out from respondents' answers and answers are grouped (Adams et al 2008). Having said that, the measurement of knowledge and attitude changes is clearly less intrusive for the user, less labour-intensive for the researcher and cheaper to perform than observation for example where actual behaviour can be investigated.
- According to the Theory of Planned Behaviour (see Section 3.4) knowledge and attitude measurement is the first indicator of eventual behaviour. There are other factors involved in a person's execution of a behaviour as previously discussed and there is no way of guaranteeing or knowing their behaviour will be as expected but as an indicator of this behaviour knowledge and attitude measurement is valid.
- The approach has been used before successfully in scenario and vignette style situations where digital libraries have been shown to change knowledge and attitudes (Berkenstadt et al 2006;Madle et al 2004).

One other concern is that measuring knowledge and attitude changes at the point of use is an evaluation of short term changes and that there is no evidence of any longer term impact on the user and their behaviour. This is a valid concern, however if an evaluation study is repeated with the same users it will be possible to see changes over time in the impact of the library. One aim of developing a model and framework for digital library impact evaluation is that it does not have to mean a one-off evaluation on a library and longer term impact can be investigated.

3.7 The Impact-ED Model

This section presents the Impact-ED (**Impact Evaluation in Digital Libraries**) model and describes its development step by step. This new model is designed to fit the gap in research identified in Chapter 2. It is based around previously published digital library dimensions (Fox & Marchionini 1999) but the model itself and its interactions is a new development as part of this research. It then discusses how the model meets the requirements for digital library impact evaluation presented in Section 2.3.4 and presents the templates that have been created to accompany the model.

3.7.1 Stage one – mapping digital library dimensions

The first step in developing the Impact-ED model was to map the digital library dimensions identified in Chapter 2 and to show the interactions between these dimensions. The aim of doing this was to allow the impact evaluation to be developed around the digital library and its work and to ensure the model was based on this. Figure 3.7.1 shows the first stage of the model.

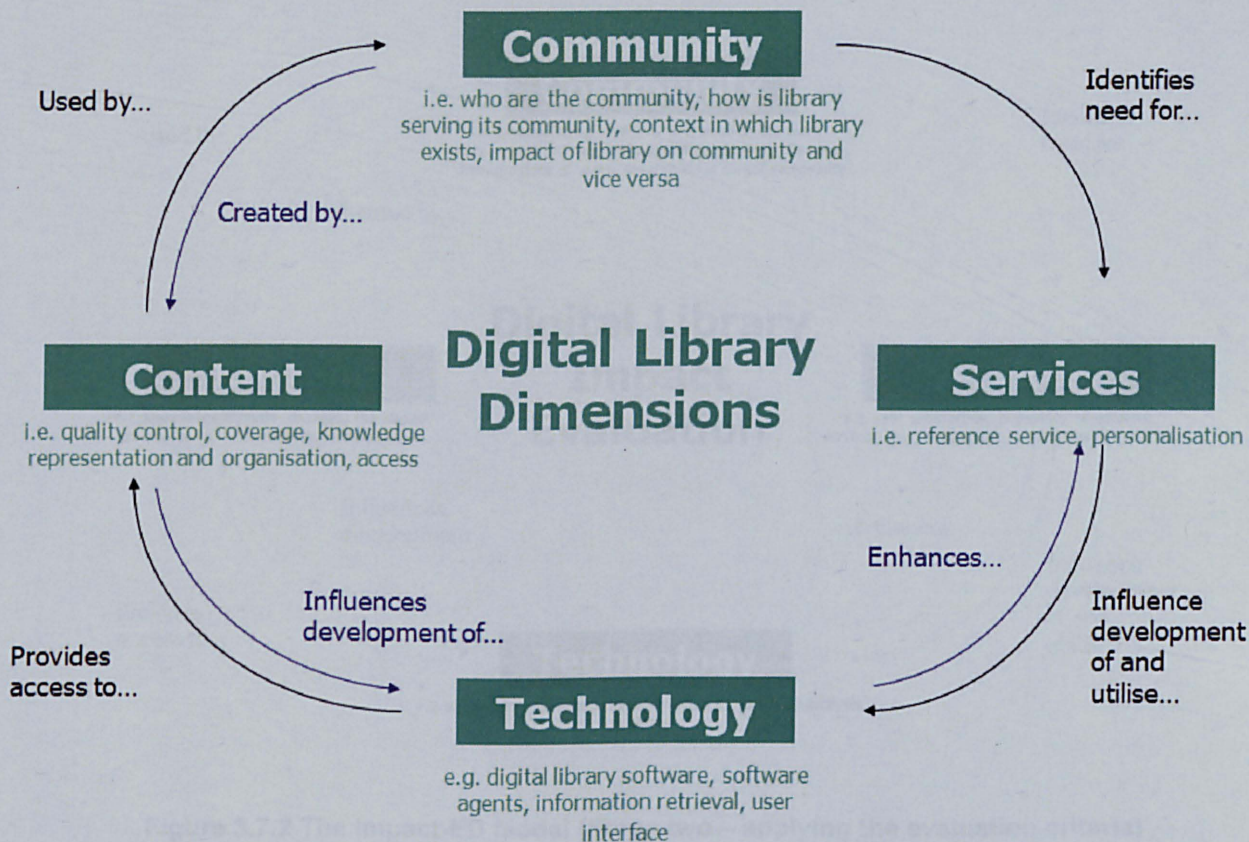


Figure 3.7.1 The Impact-ED Model (Stage one – mapping digital library dimensions)

The model gives context to the dimensions of digital library work by showing how they inter-relate and interact and what each represents. The cyclical representation of the model shows how a digital library can start from any point depending on whom and what is driving its development. It also supports the evolving nature of digital libraries as all dimensions are dynamic entities that change and develop over time.

3.7.2 Stage two – applying impact evaluation criteria

The next stage was to apply the impact evaluation criteria as identified in Section 2.5 to the model above. By mapping the criteria onto the model it becomes clear what needs to be evaluated and appropriate methods can be developed. Figure 3.7.2 shows the model at stage two. The model now incorporates the criteria for a digital library impact evaluation as related to each digital library dimension.

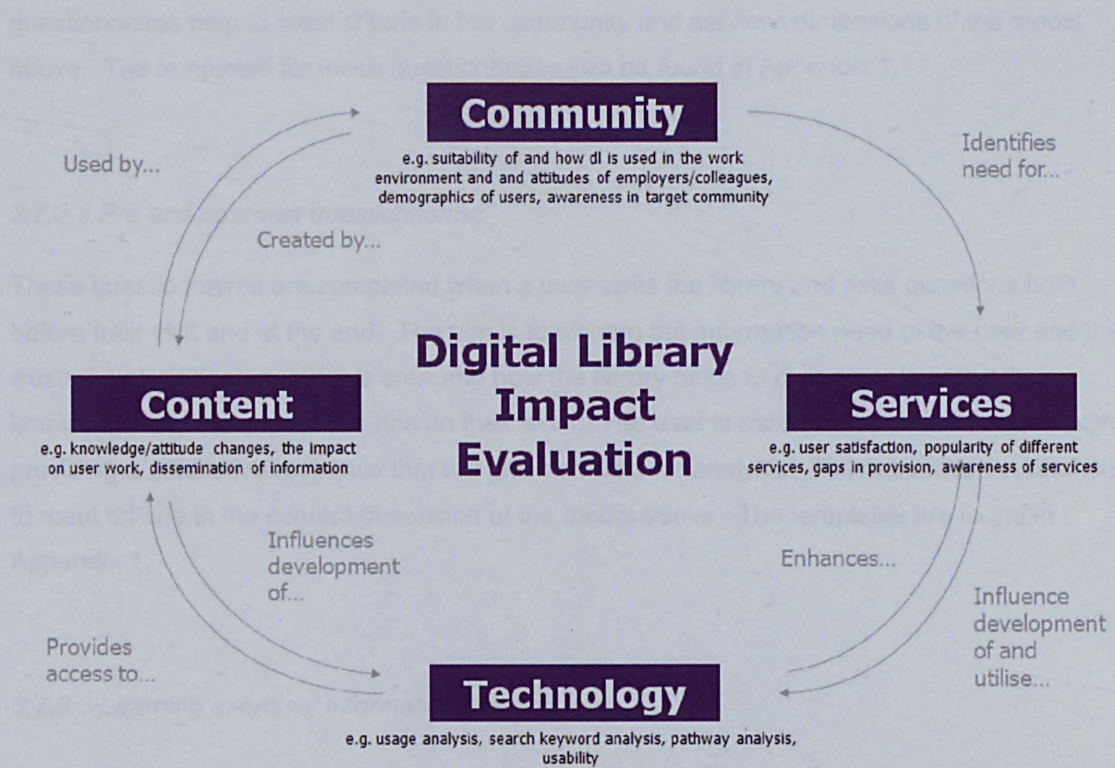


Figure 3.7.2 The Impact-ED Model (Stage two – applying the evaluation criteria)

3.7.3 Stage three – developing the methods

In order for the model to be developed into a framework for an impact evaluation, appropriate methods have to be selected and developed for data collection. Chapter 2 described the most common methods used in digital library impact evaluation research and earlier in this chapter the application of the Sense-making approach to questionnaire development was discussed. The methods that are used in each stage of data collection in the model are described below.

3.7.3.1 Impact study registration and study end questionnaire

These questionnaires will collect demographic information about the study participant, their use of the digital library being evaluated and other Internet resources and opinions of the library before the study and after. This will allow comparison of reported use and help identify any potential increase in use by the participant during the study period. These questionnaires are provided in Appendix 1. The first three questions ask about the participant's profession, experience and qualifications. Questions 4 and 5 ask about use of other resources and the Internet for sourcing evidence at work. Questions 6 to 8 are asking about use of the library for sourcing evidence at work and the final two questions, 9 and 10 ask about the perceived impact of the library on the participant's work and areas where the library could improve. These

questionnaires help to meet criteria in the community and services dimensions of the model above. The templates for these questionnaires can be found in Appendix 1.

3.7.3.2 Pre and post visit questionnaires

These questionnaires are completed when a user visits the library and asks questions both before their visit and at the end. The aim is to discern the information need of the user and their existing knowledge around this area and how the library helps to change or improve their knowledge and the impact this has on their work. The user is asked to report in their own words providing a qualitative response that will give rich data for analysis. These questionnaires help to meet criteria in the content dimension of the model above. The templates are found in Appendix 1.

3.7.3.3 Learning exercise/ Information seeking task

During the impact study users will complete a learning exercise or information seeking task. They will be asked questions about their knowledge of and attitudes to infection control, then asked to use the library to find answers to the questions before being asked the same questions again. This will enable comparison of pre and post-use questionnaire data. These questionnaires help to meet criteria in the content dimension of the model above. These questionnaires are provided in Appendix 2.

3.7.3.4 Web server log collection

Web server logs will be collected automatically to provide information about how users navigate the library when online. This can be matched to questionnaire responses to compare navigation patterns and impact to help meet criteria in the technology, content and services dimensions.

3.7.3.5 Interviews

Semi-structured interviews will be used to identify how users go about bridging the gap that is their information need when using a digital library and the impact the digital library has on their work. A social scientist has been consulted for advice on adapting the templates and interview technique. As discussed in section 3.6.2 Dervin's Sense-Making Model is considered to be appropriate for this research due to its step-by-step investigation of barriers and helps in reaching outcomes and exploration of impact on the interviewee's life. This matches well to the

aims of this research, providing a qualitative in-depth approach to add value and substance to the quantitative data collected by the other methods. The interviews provide in-depth data to add to that already obtained by other methods for all four dimensions of the model. The interview templates are in Appendix 3 and show how the interviews aim to examine the impact of the library using the step-by-step approach and identifying how the library helps users to bridge a knowledge gap.

The framework for the digital library evaluation is shown in figure 3.7.3a to show how these methods fit into the study period.

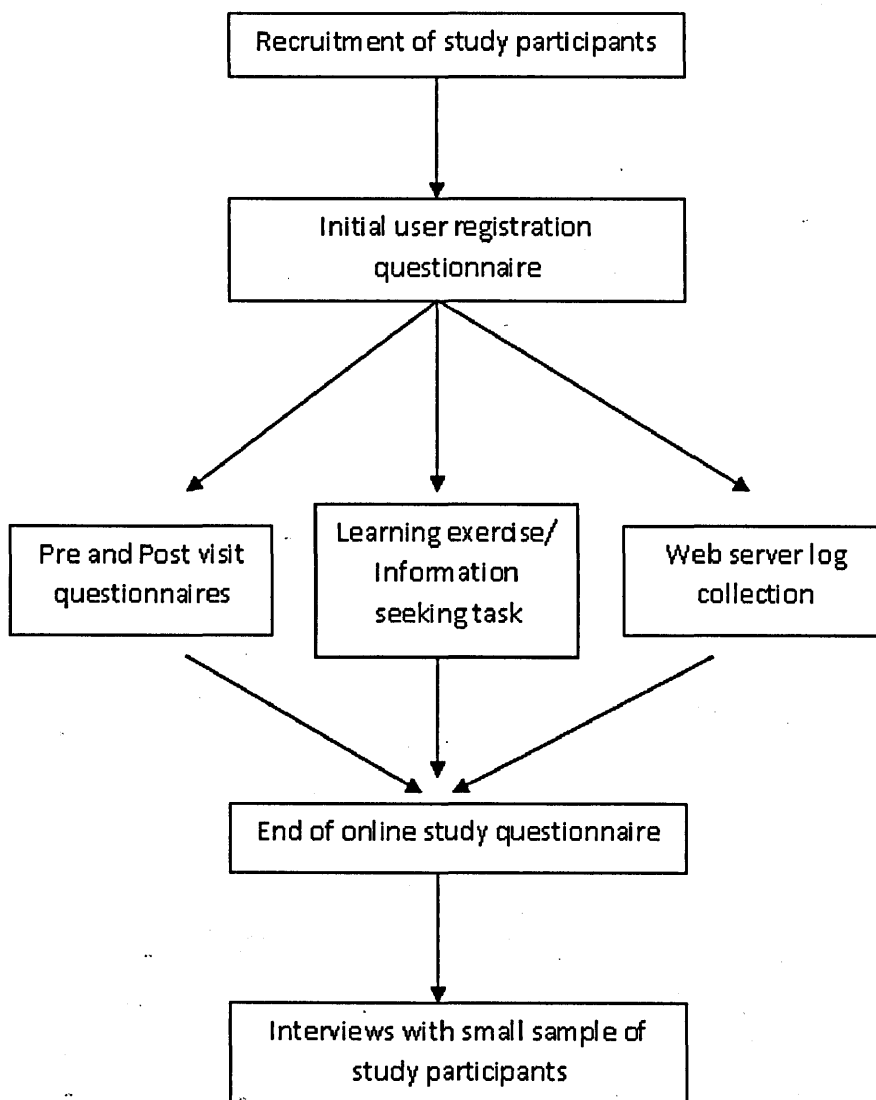


Figure 3.7.3a Framework for digital library impact evaluation methods

These methods were then overlaid onto the model in Figure 3.7.2 to produce the final Impact-ED model ready for testing as shown in Figure 3.7.3b.

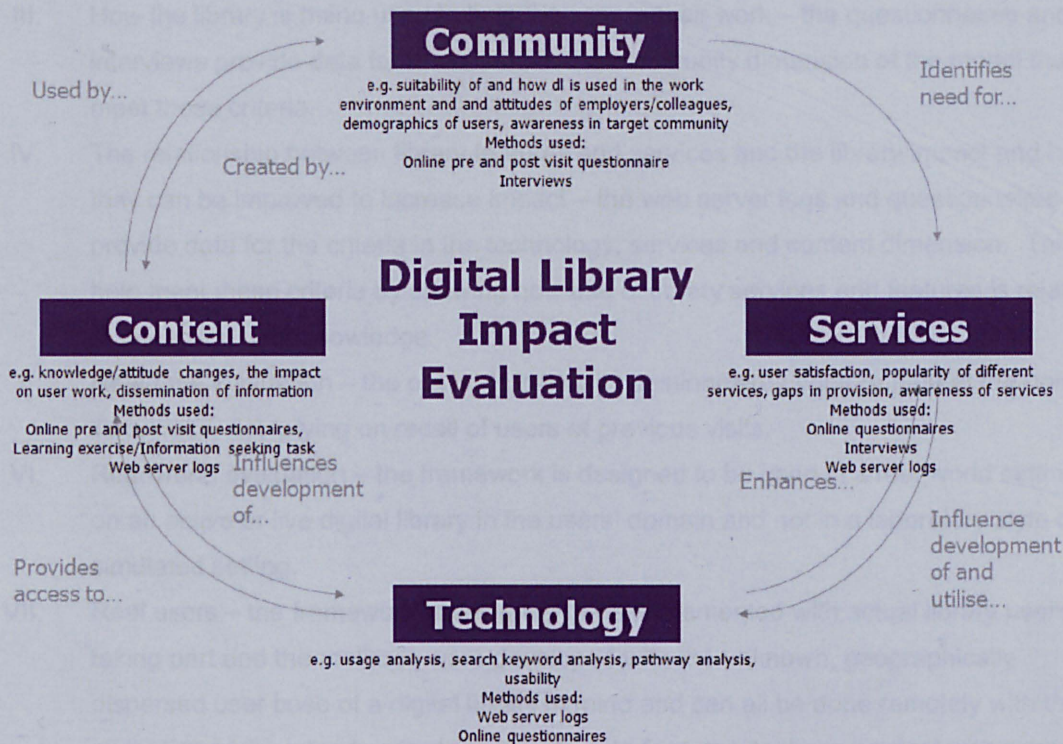


Figure 3.7.3b Impact-ED Model (Stage 3 – ready for implementation)

3.7.4 Does the model meet the requirements?

The next stage of model development is implementation which is described fully in the following chapter. Implementing the model enabled the methods to be tested. By analysing real data it was possible to see what data could be used to calculate an impact factor. The creation of an impact factor calculation is described in section 5.7 as it was necessary to obtain data before this could be developed. Chapter 6 discusses how well the model meets the requirements described in section 2.3.4. However, it is possible to estimate how well the model will meet these requirements by comparing them to the model in figure 3.7.2.

- I. The effect or impression of the digital library on the user and their work – this will be met by the registration and end questionnaires and the pre and post visit questionnaires as users are given the opportunity to describe how the library has an impact on their work at the point of visit and also in retrospect in general terms as described in the criteria for the community, services and content dimensions.
- II. The short and long-term changes the library makes to the user and their work – repeating the application of the model to several impact studies over time will enable

- the impact of a library to be compared over time by providing a consistent impact factor for comparison and also allow users to report how their use of the library has changed them and their work over time. The learning exercise and pre and post visit questionnaires will show how a visit to the library changes knowledge and attitudes.
- III. How the library is being used to help the user in their work – the questionnaires and interviews provide data for the criteria in the community dimension of the model that will meet these criteria.
 - IV. The relationship between library features and services and the library impact and how they can be improved to increase impact – the web server logs and questionnaires will provide data for the criteria in the technology, services and content dimension. This will help meet these criteria by showing how use of library services and features is related to impact on user knowledge.
 - V. Real-time evaluation – the pre and post visit questionnaires capture data at the point of library use, not relying on recall of users of previous visits.
 - VI. Real-world evaluation – the framework is designed to be used in a real-world setting i.e. on an active or live digital library in the users' domain and not in a laboratory style or simulated setting.
 - VII. Real users – the framework is designed to be implemented with actual library users taking part and the methods were developed with the unknown, geographically dispersed user base of a digital library in mind and can all be done remotely with the exception of the interview that requires face to face or telephone contact with a small sample of users.
 - VIII. Quantification of impact – calculation of an impact score following test data collection will provide this.

3.8 Summary

This chapter has presented a new approach to digital library impact evaluation to meet the requirements identified by the literature review. It describes how the Impact-ED model was developed and what methods were used to make up the framework for evaluation. The key points of this chapter are:

- Knowledge and attitude can be indicators of behaviour and their change is a valid form of measurement for a model for digital library impact evaluation due to their ability to be used with geographically dispersed and often unknown users.
- Dervin's Sense-Making model presents the metaphor of a person trying to bridge a gap to satisfy their information need and the step by step approach this describes is relevant to developing the methods used in the framework, specifically the pre and post visit questionnaires and the interviews.

- The first stage in the Impact-ED model development was to map the dimensions of a digital library identified in the literature review (Section 2.2). This resulted in a cyclical model to reflect the ongoing development of digital libraries and the varying start points for library development.
- Secondly the criteria identified from previous work and extended in Section 2.5 to meet the requirements of a digital library impact evaluation were mapped onto the model.
- Finally a framework was produced with the chosen methods and these methods were mapped onto the Impact-ED model to produce the final version for implementation.

This chapter ends with a discussion of how the Impact-ED model should meet the digital library impact evaluation requirements. The next chapter describes the methodology of the research.

Chapter 4 – Methodology

4.1 Introduction

This chapter presents the methodology used in this research, discusses how methods were chosen and developed and justifies the approach taken. It describes what was done and why. The approach taken was a deductive approach where a need was identified, a model proposed and finally the model tested. The chapter describes how the research began with a literature review (Chapter 2) that defined the current state of the art and identified where current research is lacking in digital library impact evaluation. It identifies a gap which is then filled by the proposed model developed in the next stage of the research (Chapter 3). The process of development of this model is presented and justified in section 4.3 below and the model is then tested (Chapter 5) and evaluated (Chapter 6). This chapter ends with a discussion of how the chosen methodology meets the requirements of the research.

4.2 Literature Review

A review of the literature (Chapter 2) identified the key papers in digital library impact evaluation research. The aim of the literature review was to identify the state of the art in digital library impact evaluation research and critically evaluate where it is lacking. The review was undertaken to define the boundaries of the research by defining the terms “digital library”, “evaluation” and “impact”. By researching definitions for these terms and investigating facets of digital library work an understanding of the requirements necessary for an impact evaluation of a digital library was gained and these requirements were developed and are presented in Section 2.3.4. Only digital library impact evaluations are the subject of the critical appraisal and subsequent research. This is because of the vast differences between traditional and digital libraries (Arms 2001; Chowdhury & Chowdhury 2003), hence the complexity of creating a model to fit all which is beyond the scope of this research. Critical evaluation of currently available digital library evaluation frameworks and measures and a systematic review of digital library impact evaluations published in the literature provided evidence for a gap in this research field as previous work was measured against the requirements and shown to be falling short. The search strategies to identify current digital library evaluation frameworks and previous digital library impact evaluations were as follows:

4.2.1 Digital library impact in the Healthcare domain – Search Strategy

Six bibliographic databases (British Nursing Index, CINAHL, IBSS, Medline, LISA and Science Direct) were searched in December 2007 and the issues and articles in press of relevant journals & conference proceedings (International Journal of Medical Informatics, Health Informatics Journal, Medical Informatics and the Internet in Medicine (now called Informatics for

Health and Social Care), Health Information and Libraries Journal, Journal of the American Medical Informatics Association, Journal of the Medical Library Association, MedInfo, AMIA symposium, ECDL, JCDL) published in 2007 were hand-searched. An update was performed in August 2008. The search query and inclusion/exclusion criteria were:

Search query: ((Digital OR electronic OR virtual OR Internet) AND (Librar\$ OR information OR resourc\$ OR guideline\$ OR guidance)) AND (impact OR influence OR effec\$ OR outcome) AND (medical OR health) AND (evaluation OR assessment or value)

Inclusion criteria: studies where an evaluation of the impact of a digital library is performed.

Exclusion criteria: telemedicine, decision-support systems, technology evaluations, website or database evaluations where the website or database is not a digital library (i.e. bibliographic databases with no added value such as appraisals or rankings or flat websites with no clear organisation or selection of resources as in a digital library), hybrid libraries or electronic collections of traditional physical libraries, evaluation of chat rooms or discussion forums, electronic health record, e-learning courses, non-English language papers.

The initial search in December 2007 returned 2338 unique references and an additional 180 unique references were found by the August 2008 update. Figures 3.2.1a and 3.2.1b show the processing of these results. In all 14 papers were identified as reporting digital library impact evaluations with two of these papers reporting the same evaluation leaving 13 studies for review.

4.2.2 Digital library impact in other domains – Search strategy

In addition in July 2008 a search for digital library impact evaluations in other domains was performed in LISA and Information Research Watch International and Science Direct using the following search query and the same inclusion/exclusion criteria as above. The 2008 issues and articles in press of relevant journals (Journal of the American Society of Information Science and Technology, Journal of Information Science, Aslib Proceedings, Journal of Librarianship and Information Science, Journal of Digital Information, D-Lib Magazine, Journal of Documentation, Evidence-based Librarian and Information Practice) were hand-searched.

Search query: (Librar* AND ((Digital OR electronic OR virtual OR Internet) AND (impact OR effec* OR outcome OR performance) AND (evaluation OR assessment OR value OR measure)))

The search returned 228 unique references and four of these were found to be impact evaluations of digital libraries, one of which had already been identified in the healthcare domain search. Combining both searches, nine frameworks or sets of measures were identified and 16 previous digital library impact evaluations with 13 of these being in the healthcare

domain. Data collection methods used in these digital library impact evaluations and their appropriateness in light of the requirements were also discussed. Evaluations of the impact of physical library electronic journal collections or hybrid libraries were excluded as the scope of this project only extended to digital libraries as discussed above. In essence, the literature review identifies the gap in the research in order to provide justification for the subsequent stages of the research. This gap was shown to be a lack of investigation into the impact of digital libraries on user knowledge and attitudes and a lack of triangulation of data from different collection methods in real-time real-world studies.

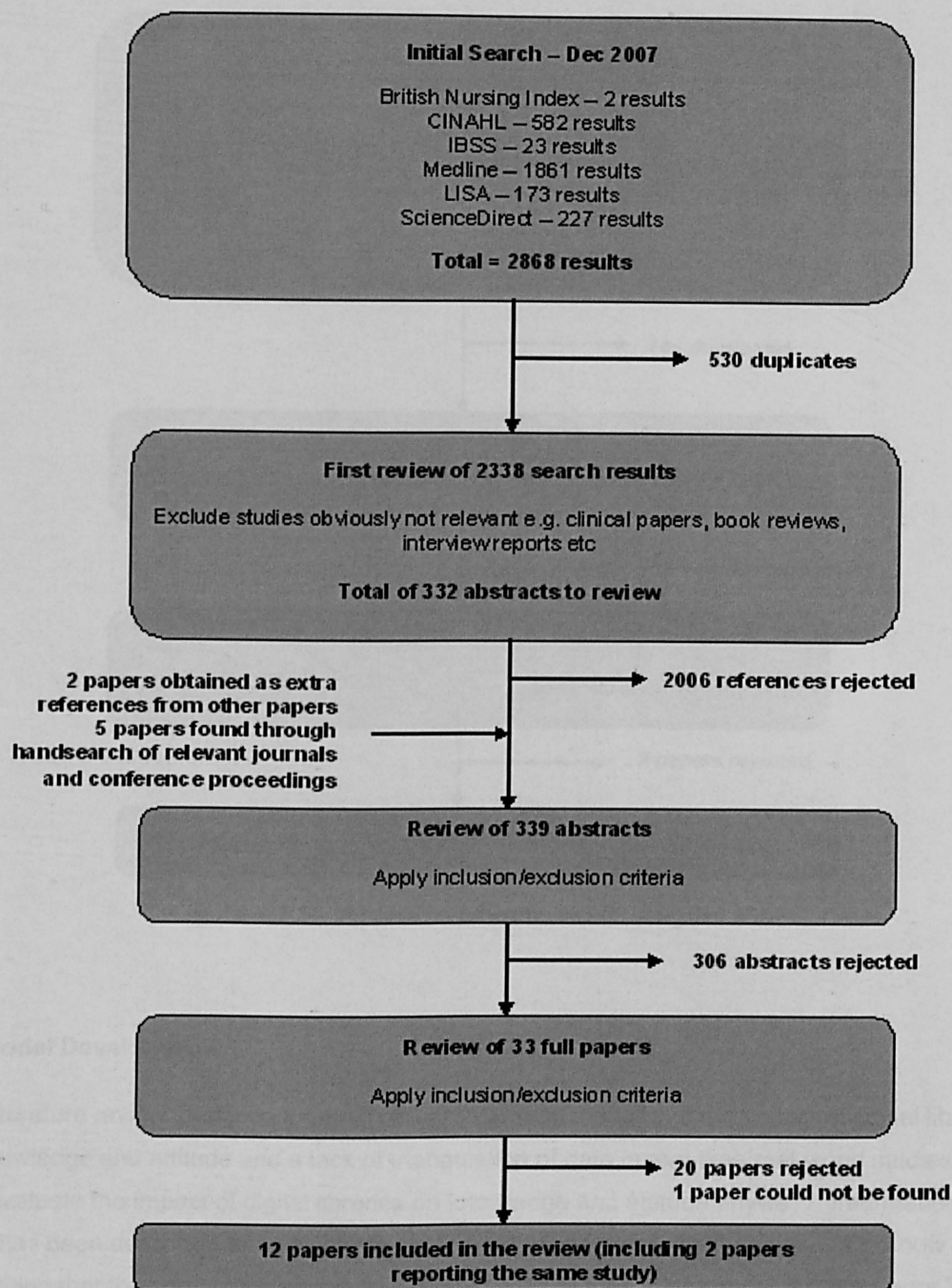


Figure 4.2.1a Initial search results December 2007

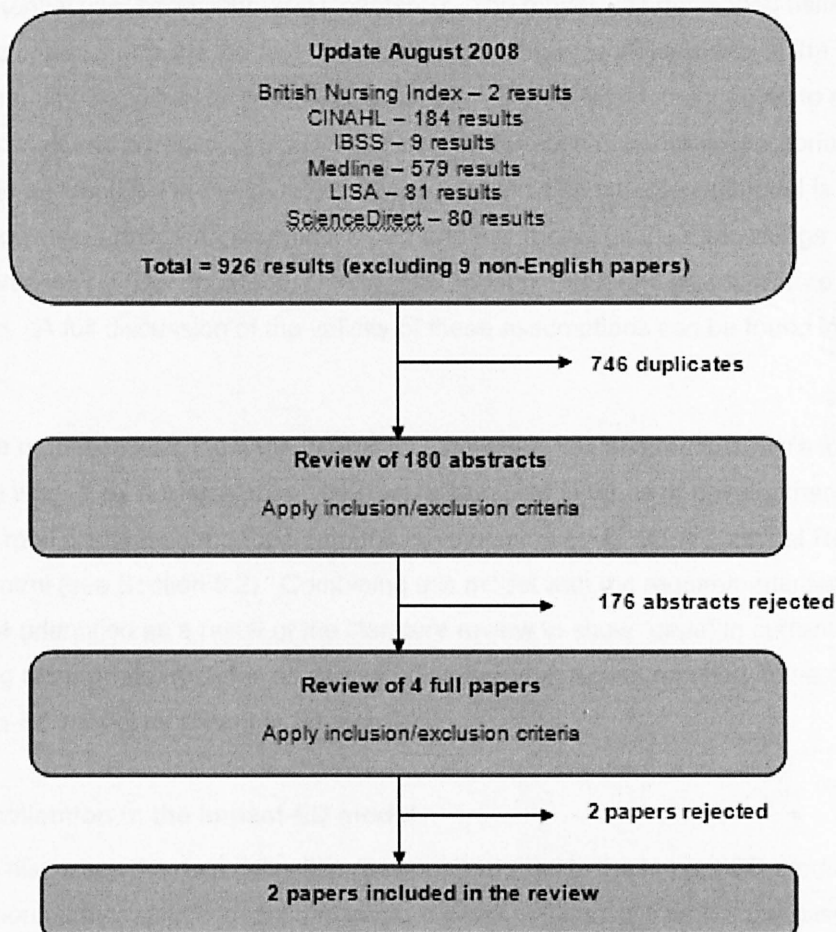


Figure 4.2.1b Update to search results August 2008

4.3 Model Development

The literature review identified a gap in research around the area of the impact of digital libraries on knowledge and attitude and a lack of triangulation of data in real-time real-world studies. But why evaluate the impact of digital libraries on knowledge and attitude anyway? Information need has been described as “a stage where the user senses that it may be useful to know something that they do not know at that particular point in time (Chowdhury & Chowdhury 2003) and Cleveland described knowledge as a refined form of information (Cleveland 1982), the implication being that users have a need to know something and a digital library can provide access to information that the user can refine to fill their knowledge gap. In addition knowledge and attitude are potential indicators of actual subsequent behaviour (Ajzen 1991). Pre and post use questionnaires have previously been used successfully by the author in preliminary work to evaluate the influence of a digital library on user knowledge and attitude about a specific subject (Madle et al. 2003; Madle et al 2004) however they have yet to be used to investigate real-time, real world use by real digital library users. Therefore this research extends previous work by using these appropriate measures of knowledge and attitude to evaluate the impact of a digital

library on potential user behaviour (see Chapter 3). The model was developed using a mapping and adapting process, around the dimensions of digital library work identified in the literature review (community, services, technology and content) (Fox & Marchionini 1999) to ensure it reflected the work and purpose of a digital library. Under each dimension appropriate methods are described as identified in the literature review. Dervin's sense-making model is suitable for evaluating how users bridge an information gap and the impact on their knowledge as a result of information seeking (Dervin 2003b; Dervin 1997; Wilson 1999) and was therefore applied to this research. A full discussion of the validity of these assumptions can be found in Chapter 3 of the thesis.

Initially in the model development the interactions between Fox and Marchionini's four facets of digital library work (Fox & Marchionini 1999) were identified in terms of development of a digital library. The model was then mapped onto the development cycle of the National Resource for Infection Control (see Section 5.2). Combining this model with the requirements set out in Section 2.3.4 (identified as a result of the literature review to show "gaps" in current research) and selecting appropriate methods as described in the next section resulted in the development of the Impact-ED model as shown in Section 3.7.

4.3.1 Data collection in the Impact-ED model

This section discusses the data collection methods included in the Impact-ED model. The actual questionnaire content is described in more detail in Chapter 5 where the case study library (the National Resource for Infection Control – NRIC) is presented. The methods used have all been identified as ways of collecting data to evaluate digital libraries and are reviewed in Section 2.4. They include questionnaires, web server logs and interviews. Their use in evaluation studies is well documented and their suitability for this research evident as discussed in Section 2.4 (Adams & Blandford 2002; Bell 1999; Blandford et al. 2008; Crawford 2000; Huntington et al 2005). All questionnaires were administered online via the Lotus Notes platform and integrated into the NRIC library. The researcher was responsible for their development and creation in Lotus Notes with support from the NRIC technical staff in integrating this with user login.

- Study beginning and end questionnaires were developed to collect demographic data about participants as well as general perceptions about the library both before and after completing the study. These were based on questionnaires used in previous work (Madle 2009).
- Pre and post visit questionnaires were developed using templates available from Dervin's sense making model website (Rajendram 1997). These were adapted to collect information online rather than on paper. Users were presented with the first questionnaire upon logging into the library and the post use questionnaire upon logging out. A pilot study was performed and questions reworded where necessary.

- A learning exercise questionnaire was developed specifically for the library subject domain with the help of a domain expert (Sue Wiseman – Consultant to the Department of Health and content coordinator of the NRIC library) and piloted before use following which some questions were reworded.
- Web server logs were collected automatically by the server on which the library was located. These were in Lotus Domino format saved in text files. They were analysed from the raw log data in Microsoft Excel by the researcher who has previous experience in this field. As users were asked to login the problems of sharing or changing IP addresses was avoided as users could be tracked by their username in the logs.
- The interviews were conducted at a location of the interviewee's choice to reduce the burden of participation and took between 20 and 60 minutes. They were recorded on tape and later transcribed by the researcher.

Screenshots of the questionnaires are shown below in figure 4.3.1a and figure 4.3.1b.

The screenshot shows a web browser window with the URL http://www.nric.org.uk/NRIC_Eval.nsf/RegistrationQuestionnaire?OpenForm. The page header features the NRIC logo and the NHS logo. The main content area is titled "Registration Questionnaire for the NRIC Evaluation" and contains the following text:

Please fill in the following questionnaire answering each question as fully as you feel able. There are no right or wrong answers. The aim of this questionnaire is to gain an understanding of how much and why you use NRIC and the impact this has on your work. When you have finished completing the questionnaire please click the "SUBMIT" button at the bottom of the page.

Many thanks for your participation in this study.

Gemma Madie
City University

1. Please enter your

Name:

Job Title:

Current Profession (e.g. Nurse, Microbiologist):

The county you work in (If not UK enter country):

Do you ever use a shared computer for accessing NRIC?

☐ Yes

☐ No

Where did you hear about this evaluation?

2. What is your highest level qualification?

Figure 4.3.1a The registration questionnaire for the evaluation study

Before you visit NRIC.....

Thank you for logging in to NRIC today. If you are using NRIC to look for evidence/information for your work then please fill in the following 3 questions before you visit NRIC, answering each question as fully as you feel able. There are no right or wrong answers. The aim of this questionnaire is to gain an understanding of what your knowledge and attitudes are before using NRIC. You will also be asked to complete a short questionnaire when you have finished using NRIC. This is very important as without this post-use questionnaire we cannot evaluate whether NRIC is having any impact on your work so please do complete this. When you have finished completing this questionnaire please click the "SUBMIT" button at the bottom of the page and this will take you to NRIC. If you are not using NRIC to find evidence/information for your work or you have already completed this questionnaire at least twice before please go straight to the [NRIC home page](#).

Many thanks again for your participation in this study.
Gemma Madle
City University

1. What information are you hoping to find during your visit to NRIC?

2. Before searching NRIC, do you have any knowledge or attitudes, or conclusions about the information you are trying to find? If yes, what are they and what has led you to them?

Figure 4.3.1b The Pre visit questionnaire in the NRIC evaluation study

An expert in questionnaire development and interviewing skills (Anne Adams of the Open University) was consulted by the researcher to suggest changes to the templates before the study began. Ethical approval was not obtained as all data was anonymised and no individual identified in any data reporting. Permission was gained to perform the study on the NRIC library from the NRIC Advisory Board. Respondents were recruited via an advert or email shown in Appendix 5. The email was sent to all 1800 (approximately) members of the NRIC mailing list and the advert displayed on the Infection Prevention Society Website Forum. The number of respondents for each stage of the study is shown in Chapter 5. It is difficult to calculate a recommended sample size as the exact number of library users is unknown. In December 2007 the number of unique IP addresses visiting NRIC was just under 3000 so using this as a guide a sample of 357 would be necessary to obtain a 95% confidence level in any results. However if the subscribers to the newsletter (1800) were classed as the target users then the sample size would need to be 333 (Salant & Dillman 1994). Both of these figures is optimistic for a 3 month study such as that proposed and it is likely this will be a smaller opportunistic study due to constraints of the project and funding. However this work is a proof of concept and can be extended in future research to increase the sample size accordingly.

Part of the originality of the model is the triangulation of data combined from all these methods, something that has been identified as key for future evaluation research of digital resources (Williams & Gunter 2006). As users logged in to use the library their activity could be directly linked to their questionnaire responses. The model was developed to include a stepped

approach to data collection and templates for data collection for each of these steps were produced (See Appendix 1). These templates are intended to be generic and suitable for adaptation for any digital library following further research in other domains. They were developed to aid future evaluators in easily adapting the model for their digital library and in running an impact evaluation themselves. It also provides a clear display of how the data collected enables the evaluation model to meet the requirements set out in Section 2.3.4. The questionnaires used at the beginning and end of the study allow collection of demographic data, data about user satisfaction with and awareness of services and use of the digital library in the work context as well as self-reported impact on user work. The questionnaires in the learning exercise/information seeking task show how users are able to answer questions known to be answered by specific documents. Another original contribution to digital library impact evaluation research is the pre and post visit questionnaires that allow investigation into the reasons for actual visits to the digital library and how user knowledge compares before and after these visits. Users are asked to describe the impact they expect their knowledge to have on their work situation and their subsequent actions. The web server logs provide data to support all of these questionnaires by showing how often users are accessing the digital library and the pages or documents they visit whilst online. This is complemented finally by the interviews where users have the opportunity to explain in more depth how they use the digital library to overcome problems or knowledge gaps in their work and the impact the library has on them and their work. Users email addresses were also collected so that follow up studies could be performed at a later date.

4.3.2 Data analysis in the Impact-ED model

As discussed in section 2.5 the triangulation of data and analysis on an individual user is a feature of this research that has not yet been performed in digital library evaluation (Huntington et al 2005; Williams & Gunter 2006). User profiles are created from data collected throughout an impact evaluation study using the Impact-ED model. Templates were developed for data analysis focussing on the requirements and to show how data collected could meet these requirements. Following implementation of the model on the case study digital library the templates were refined and an analysis of the data provided impact summaries for the digital library evaluation relating to each of the four dimensions of digital library work (Community, Services, Technology, Content) and is presented for the NRIC library in Section 5.6.5. The difficulty of producing a standard set of criteria for all digital libraries given their diversity in content, audience and technology has already been highlighted (Chowdhury & Chowdhury 2003) (Chowdhury et al 2006; Mathur 2005), however the benefit of a standardised evaluation framework for digital libraries is recognised as important for developing the current state of evaluation research from one off projects into more substantial evaluation research (Chowdhury et al 2006). For this reason a scoring system to compare impacts across digital libraries was developed. The data collected from the case study and subsequent data analysis allowed the creation of an impact score based on the impact of the library on user knowledge and attitude

and subsequent intended behaviour. Individual scores can be calculated for users, an overall score for the library or scores related to the purpose of use of the information gained and these can be included in the impact summary. Also included in the impact summary are details of where the library can improve its impact i.e. what features are helping its impact on the user and what features are hindering. This allows for subsequent improvements to the library to be made and a comparison of the impact of the library over time, i.e. an iterative approach or formative approach to evaluation where the library can be modified accordingly following each evaluation and subsequent changes in impact recorded. The case study of the NRIC library provides an example of how the model can be used to provide such information about digital library impact.

4.3.3 Testing of the Impact-ED model

The model was tested on the case study digital library the National Resource for Infection Control (NRIC - <http://www.nric.org.uk>). This library is funded by the UK Department of Health and is described in detail in Section 5.2. The NRIC was chosen as it is a living, breathing digital library, in use by professionals in the real world and therefore suitable for implementing the Impact-ED model. In addition, healthcare digital libraries are particularly keen to evaluate their impact due to the potential role they play in patient care (Cullen 2004). Full access to this library, its users and web server logs was obtained for the purpose of this research. The process of participant recruitment, data collection and the results obtained are presented in full in Chapter 5. The first stage of applying the model was to map the digital library onto the graphic representation of Impact-ED as shown in Figure 3.7.1. The templates for the questionnaire and interview data collection stages were then adapted according to the content and services provided by the library. Only by collecting data from a case study library was it possible to refine the data analysis templates of the model and enable the development of an example digital library impact summary and score. This process of applying the model to a case study library is then discussed in Chapter 6 and its success is critically reviewed.

4.4 Summary

This chapter has presented the methodology of the research, described what has been done and provided justification for the use of existing methods and development of new models and templates. The methods chosen have enabled the research to meet the objectives as presented in Section 1.3 as follows:

- 1. Review the literature to identify the current status of impact evaluation research in digital libraries*

Performing a literature review enables identification of the state of the art essential to ensure work is not being duplicated.

II. Identify a need for a digital library impact evaluation model and identify requirements for digital library impact evaluation

The work in Chapter 3 resulting from the gap in research identified following the literature review meets this objective by presenting a new approach using knowledge and attitude changes as indicators of impact of the library on subsequent behaviour and measuring these knowledge and attitude changes by applying Dervin's Sense-Making model to development of the data collection methods.

III. Develop a model and framework for digital library impact evaluation with a method of producing an impact score

To develop a model or framework that can be used to evaluate digital library impact using this new approach: to include producing templates for ease of reproducibility by future evaluators; to be universal i.e. potentially adaptable for any digital library in any domain; to be objective i.e. not relying on user self-reported impact from a single data source but triangulating data from different sources to provide a more objective picture of impact; to enable production of an "impact summary", a short brief describing the impact of the digital library to which the model has been applied and an "impact score" to allow comparison between libraries and over time. The chosen methodology achieves these objectives by creating the templates around the requirements of a digital library impact evaluation model to ensure they will provide the added value to previous work in this field. The data analysis methods include triangulation of data from different sources (questionnaires, web server logs, interviews) on an individual user basis to result in a concise summary of the impact of the digital library that can be presented at stakeholder meetings or in a report. The testing of the model on a case study library permitted development of an impact score as a function of the impact of the library on user knowledge and attitude. Without testing the model and collecting real data it would not have been possible to develop this scoring system.

IV. Implement the model and framework on a case study digital library

Testing the model on a case study real world library allows refining of the templates and provides an example of an impact summary. Using a real world digital library in use by real users ensures the test evaluation is subject to the same constraints and barriers that are present in future evaluations for which the model is used.

V. Evaluate the model and framework in terms of how well they meet the requirements for a digital library impact evaluation and refine as necessary

VI. Identify how the model can be developed in future research

A discussion of how well the model meets the requirements for digital library impact evaluation is found in Chapter 6 and the limitations of the model are also discussed. This chapter also identifies areas for further research and development of the model that have arisen as a result of this project.

This presentation of the objectives has shown how the chosen methodology has allowed the research to meet these objectives. The aim of this chapter was not to describe the results of the research but to show how these results were achieved. The thesis now continues to present in detail these results in the next chapter.

5.1 Introduction

This chapter presents the real world library that was used to test the model and describes the study that took place. The National Resource for Infection Control is a well used digital library funded by the UK Department of Health and has an active user group who are involved in development and promotion of the library. Testing the model and framework methods is essential in order to refine them and ensure they produce valid and appropriate data. The chapter goes on to describe how the results of the test impact evaluation were used for the development of an impact score. The benefits and weaknesses of this impact score calculation are discussed to close the chapter.

5.2 The case study – The National Resource for Infection Control

The National Resource for Infection Control is the digital library chosen as the case study. The researcher has access to this library and its users who are an active community. The National Resource for Infection Control (NRIC) was launched in May 2005 in response to National Audit Office (2000/04) recommendations for a national infection control manual (Wiseman et al. 2006). The project funded by the Department of Health (UK) and endorsed by the UK National electronic Library of Infection (www.neli.org.uk) covers a broad range of infection prevention and control and infectious diseases information. Figure 5.2a shows a screenshot of the library home page, figure 5.2b a search results page and figure 5.2c a catalogue card. Figure 5.2d shows the first stage of implementation – mapping the library onto the Impact-ED model.

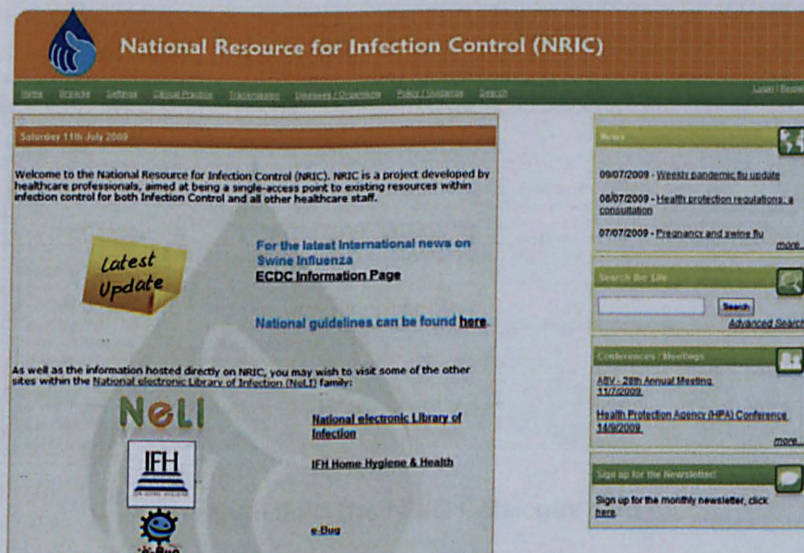


Figure 5.2a The NRIC Library Home Page

National Resource for Infection Control (NRIC)						
Home Browse Settings Clinical Practice Transmission Diseases / Organisms Policy / Guidance Search Login / Register						
Diseases / Organisms - HIV						
View all HIV resources:						
Title	Type	Level of evidence	Source	Published	Review	
Sexual Health and HIV	Web directory	Evidence cited	Department of Health (DH)			
Sexually transmitted infections (STI) - an update, March 2005	Best practice Review	Evidence cited Professional opinion	British Medical Association (BMA)	25/03/2008		
AVERT - Healthcare Workers and AIDS prevention	Web directory	Evidence cited	AVERT (an International AIDS Charity)	02/06/2009		
Expert Advisory Group on AIDS Annual Report 2008	Other	N/A	Department of Health (DH)	28/05/2009		
Keeping Europe healthy: ECDC in action	Best practice Surveillance data	Evidence cited Professional opinion	European Centre for Disease Prevention and Control (ECDC)	23/02/2009		
HIV (DH)	Web directory	Evidence cited	Department of Health (DH)	01/02/2009		
Blood Borne Viruses (BBVs) and Occupational Exposure	Web directory	Evidence cited	Health Protection Agency (HPA)	01/02/2009		
European Centre for Disease Prevention and Control/WHO Regional Office for Europe: HIV/AIDS surveillance in Europe 2007	Surveillance data	Evidence cited	European Centre for Disease Prevention and Control (ECDC)	01/12/2008		
HIV and AIDS: information and guidance in the occupational setting	Web directory	Evidence cited	Health Protection Agency (HPA)	26/11/2008		

Figure 5.2b The NRIC Search Results Page

National Resource for Infection Control (NRIC)			
Home Browse Settings Clinical Practice Transmission Diseases / Organisms Policy / Guidance Search Login / Register			
Review			
Full Review Click here for full review	Review by Sue Wiseman	Questions this resource addresses The web directory provides information and key documents on sexual health issues for healthcare workers and the public...	
Resource Details			
Doc Title Link Author(s) Abstract	Sexual Health and HIV Click here for the original resource http://... Department of Health As part of a comprehensive strategy to improve the sexual health of the population, the Department of Health is working to reduce the prevalence of sexually transmitted infections and HIV, reduce unintended pregnancies (particularly teenage pregnancies) and improve the range, access to and quality of service provision. On these pages you will find more information and guidance on sexual health including contraception, abortion and STIs and HIV.		
Publisher Source Publication Type Category Level of Evidence Coverage Format Language Access Rights Date of publishing Date of posting	Department of Health (DH) Department of Health (DH) Web directory Control, Epidemiology, Investigation, Prevention, Public information, Treatment Evidence cited England Pdf English Free 26/07/2005		

Figure 5.2c The NRIC Catalogue card

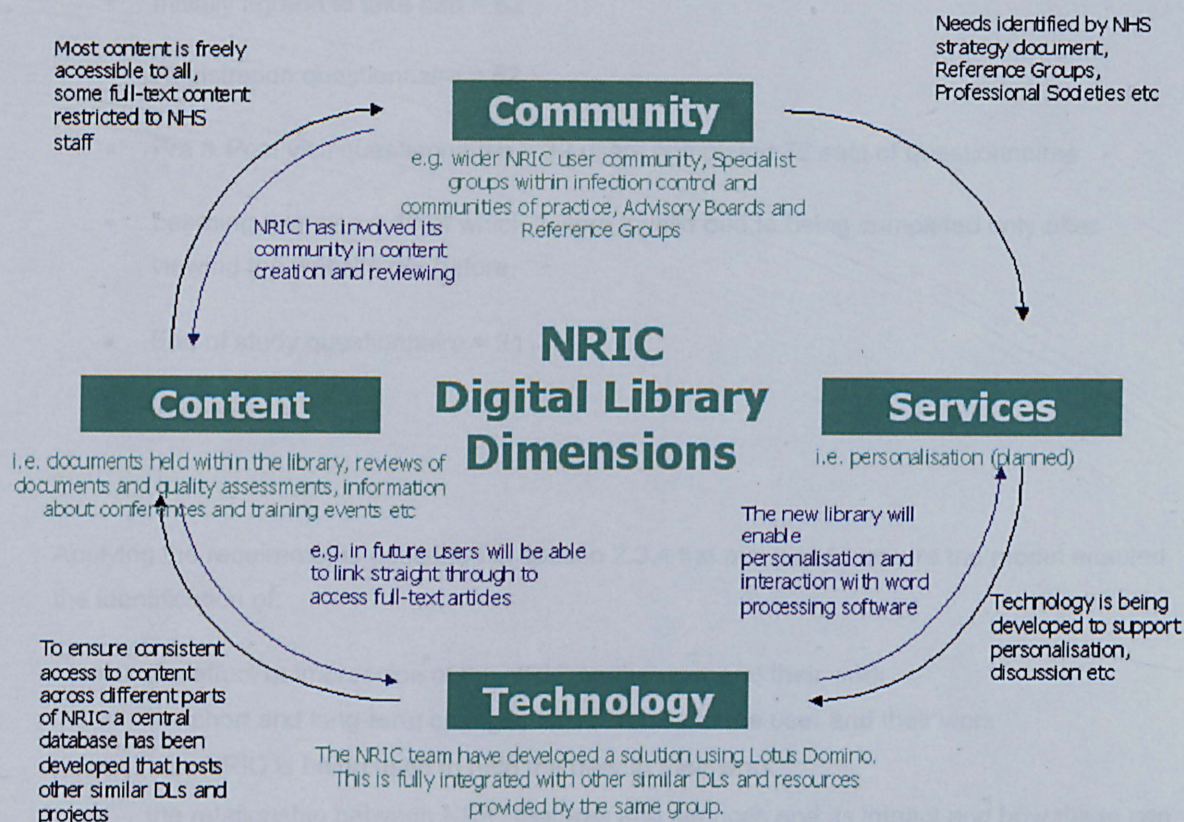


Figure 5.2d Mapping the NRIC library onto the Impact-ED model

5.3 Proposed sample population and setting

The main target group for the chosen digital library is UK Infection Control Nurses and it was anticipated that the sample population would mainly consist of this group however other professionals such as microbiologists and doctors were not excluded. Participants were recruited through relevant mailing lists, including the NRIC contacts database, an advert on the site and in relevant newsletters and through personal contacts (see Appendix 5 for the recruitment email).

5.4 Data Collection

Potential participants were recruited by an advert on the NRIC website, through the NRIC mailing list (approximately 1800 members), via a post on the Infection Prevention Society (IPS) website forums and through contacts in the IPS South West branch. Numbers to participate were as follows:

- Initially agreed to take part = 62
- Registration questionnaire = 52
- Pre & Post visit questionnaires = 32 users completed 72 sets of questionnaires
- Learning exercise = 10 of which 2 were invalid due to being completed only after viewing the website not before.
- End of study questionnaire = 31
- Interviews = 5

Applying the requirements described in section 2.3.4 the aim was to ensure the model enabled the identification of:

- the effect or impression of the NRIC on the user and their work
- the short and long-term changes NRIC makes to the user and their work
- how NRIC is being used to help the user in their work
- the relationship between NRIC features and services and its impact and how these can be improved to increase impact

The methods used to collect data were as described in a previous chapter in section 3.7.3 and were used as follows:

- Study registration (Feb '08) and end questionnaires (May '08) – to find out who uses NRIC, how and when they were using it and for what reasons, compare answers before and after the study and to provide an opportunity for users to comment on services and suggest improvements.
- Information seeking task/learning exercise (May '08) – to examine how well users could complete an information seeking task i.e. find specific documents and find answers to questions using NRIC
- Pre and post questionnaire (Feb-May '08) – to discover for what reasons people use NRIC at the point of use in their own words, what they know already to compare with what they think they have learnt from using NRIC and how they will apply this to their work
- Web server log collection (Feb – May '08) – to collect data on how the participants actually navigate the library and see how this compares with how they report using it and the impact it has on their work
- Interviews (July - Aug '08)– to provide more in-depth information in user's own words about how the site has an impact and how it can be improved

Weekly reminder emails were sent to all study participants to encourage them to login when they visited the library and to complete the pre and post visit questionnaires. The next section discusses how the data obtained was analysed to produce results.

5.5 Data analysis

Data was analysed according to the criteria set out in section 2.5 based around the four dimensions of the Impact-ED model (community, services, technology and content). Initially questionnaire data was entered into Excel spreadsheets and for the qualitative pre and post visit questionnaires data was grouped according to reason for visiting, type of information sought, and whether knowledge was gained or changed/strengthened. A full coding sheet was then developed and can be found in Appendix 4. Qualitative answers were put into groups based on the responses provided by users. The data was then linked to web server log data for each visit to identify what services were used, which documents were viewed and what navigation strategy was followed (i.e. browsing, searching or both). The learning exercise/information seeking task questionnaires were matched and changes were scored according to whether a question was answered correctly before or after visiting the library. Interview transcripts were analysed to identify quotes relevant to each criteria listed in section 2.5. The data from all the different methods was linked on an individual user basis, something not previous done as discussed in Chapter 2. All the data was then collated to show how it meets the digital library impact evaluation criteria. The results are discussed in the next section and the development of the impact score as a result of the analysis follows the results.

5.6 Results

The results are structured around the criteria for digital library impact evaluation as described in section 2.5. This ensures that all criteria are met by the evaluation.

5.6.1. Community:

5.6.1.1 How the digital library is used in the work setting and what are the reasons for use

The registration and end questionnaires showed that users tended to overestimate the frequency of their visits before the study period began, with more conservative reports at the end of the study (Figure 5.6.1.1a). Also either they had overestimated the actual frequency or that they were not always logging in to the library to visit it as actual visits were much lower than the reported use (Figure 5.6.1.1b).

Reasons for use varied both in the reported reasons in the registration questionnaire (Figure 5.6.1.1c) and in actual reasons for specific visits from the pre and post visit questionnaires (Figure 5.6.1.1e). The former were selected from a multiple choice question and the latter were real reasons in the participants own words which were then grouped into the reasons shown in the chart. The majority of the information sought in NRIC was evidence to support or improve existing knowledge or practice but also a significant number of visits were to support personal education or staff training.

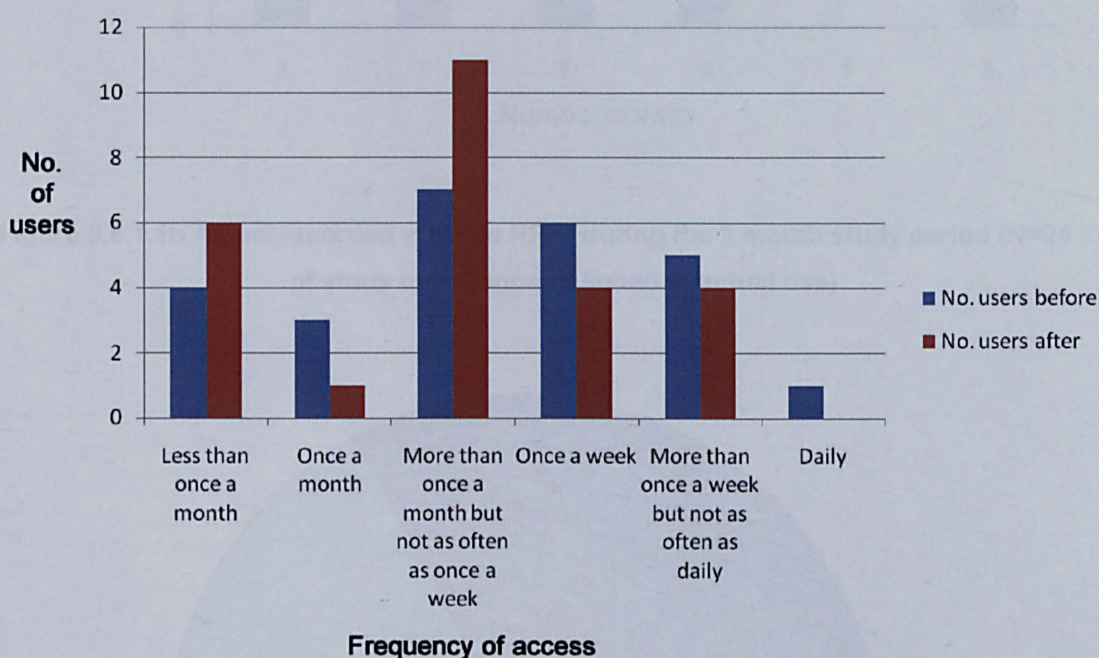


Figure 5.6.1.1a Reported frequency of use of NRIC (N=52 Registration Questionnaire)

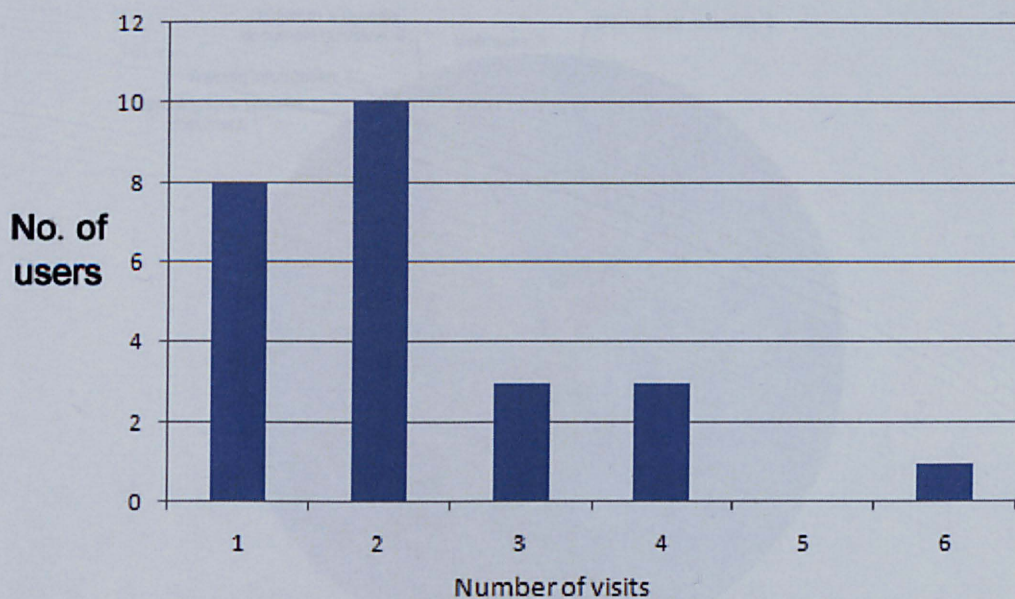


Figure 5.6.1.1b Actual recorded visits to NRIC during the 3 month study period (N=25 End of study questionnaire linked to actual use)

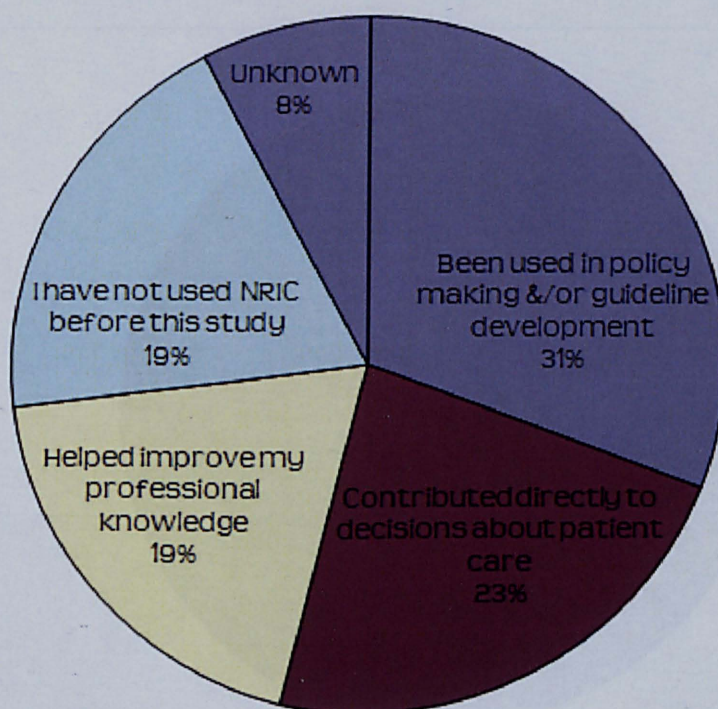


Figure 5.6.1.1c Reported reasons for use of NRIC (N=72 Pre and Post visit Questionnaires)

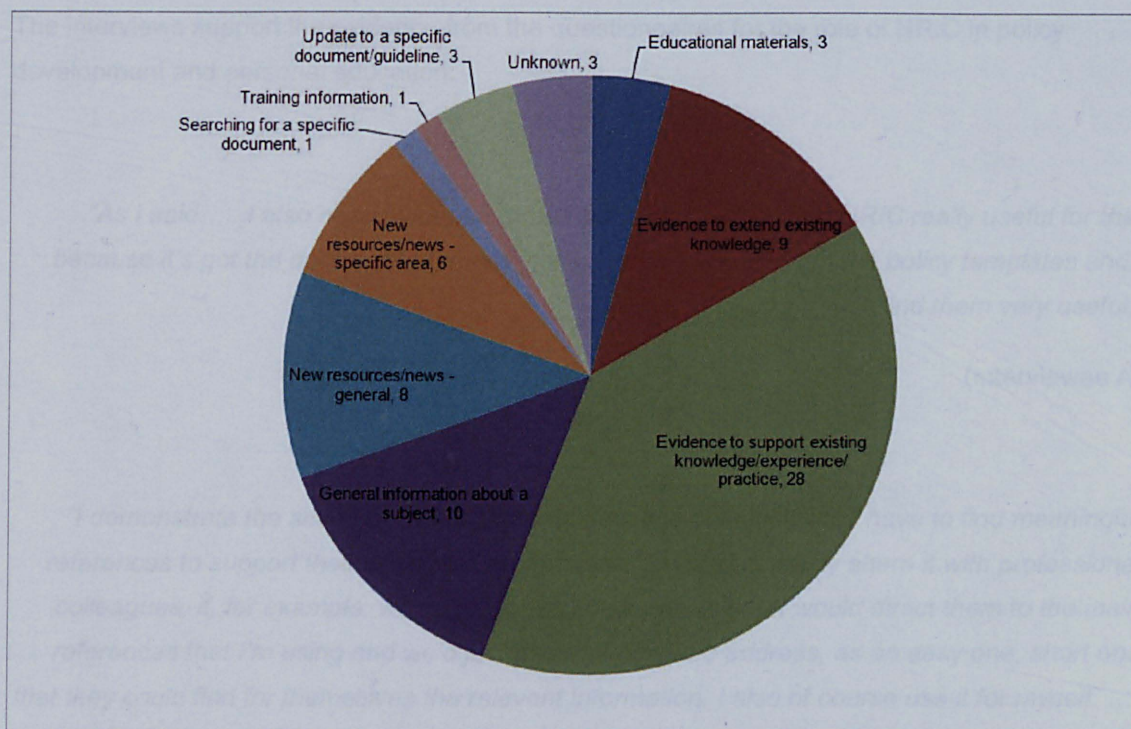


Figure 5.6.1.1d Type of information sought (N=72 Pre and post visit questionnaires, numbers in chart represent number of participants)

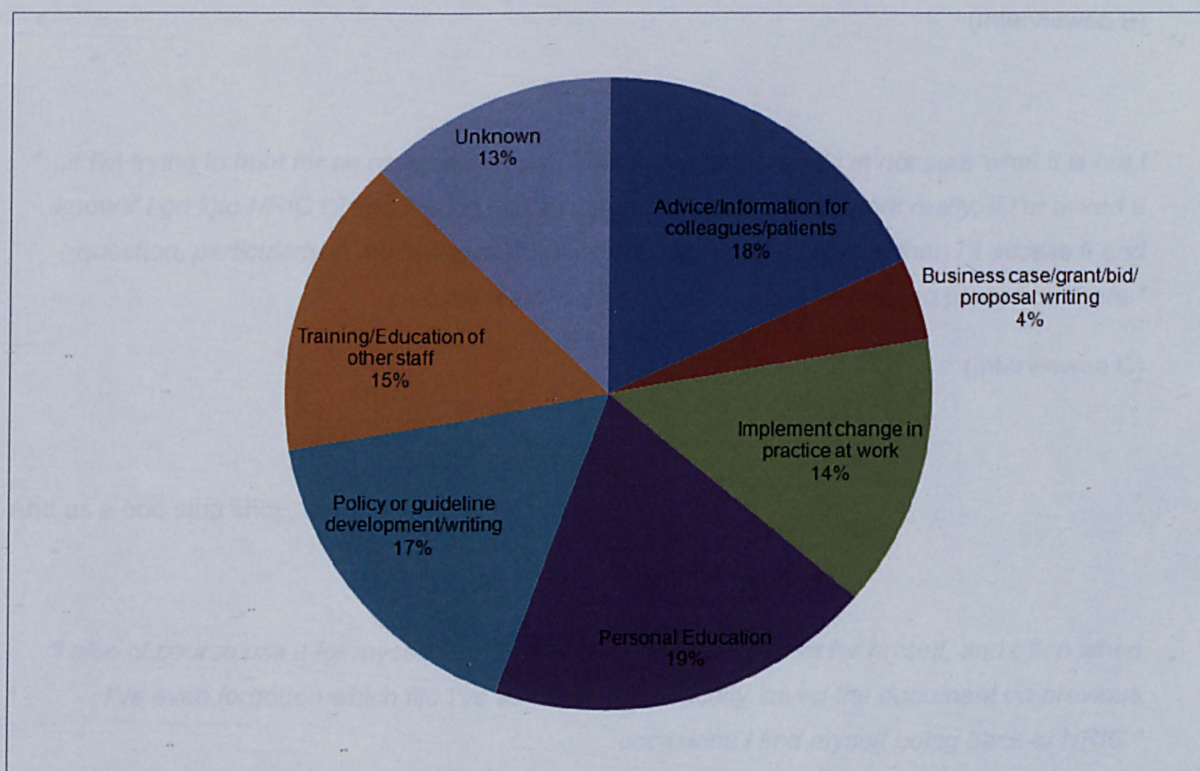


Figure 5.6.1.1e Actual reasons for use for specific visits (N=72 Pre and Post visit questionnaires)

The interviews support the evidence from the questionnaires for the role of NRIC in policy development and personal education:

"As I saidI also need evidence for the policies,And I find NRIC really useful for that because it's got the documents for everything in there. It's also got the policy templates and I find them very useful."

(Interviewee A)

"I demonstrate the site to all of my students because obviously they have to find meaningful references to support their academic assignments. I would certainly share it with professional colleagues, if, for example, we were working on a policy then I would direct them to the main references that I'm using and we'd just use that one web address, as an easy one, short one that they could find for themselves the relevant information. I also of course use it for myself. it's a lazy quick access point for myself, and often when I've even forgotten which file I've actually electronically saved the document on previous occasions I find myself going back to NRIC."

(Interviewee B)

"...if I'm trying to hunt for an assignment, um, hunt for an article and I'm not sure what it is but I know if I go into NRIC I'll find it quite quickly. I tend to use it a lot in work really, if I'm asked a question, particularly in reviewing policies which I've been involved in then I'll access it and have a look at other policies that have been placed on there."

(Interviewee C)

And as a one stop shop, rather than visiting source websites:

"I also of course use it for myself. it's a lazy quick access point for myself, and often when I've even forgotten which file I've actually electronically saved the document on previous occasions I find myself going back to NRIC."

(Interviewee B)

"It's where I go to get the main infection control guidance and advice...um...or if I'm not sure what's new I look there to see what there is as well because we don't always get the information from the Department of Health because it goes to the NHS automatically but not to the HPA automatically."

(Interviewee E)

5.6.1.2 The suitability of the work environment for integrating the digital library into work practice e.g. access to the Internet & Acceptability of the digital library by employers/colleagues i.e. support given for using the digital library in work time & space

Users generally felt that access to the Internet was easy in their workplace and there was a feeling of support from employers to use such resources although participants were more likely to agree with the former than the latter (Figure 5.6.1.2). There was no difference in the impact of NRIC on users who had good access and employer support to use such resources and those who did not.

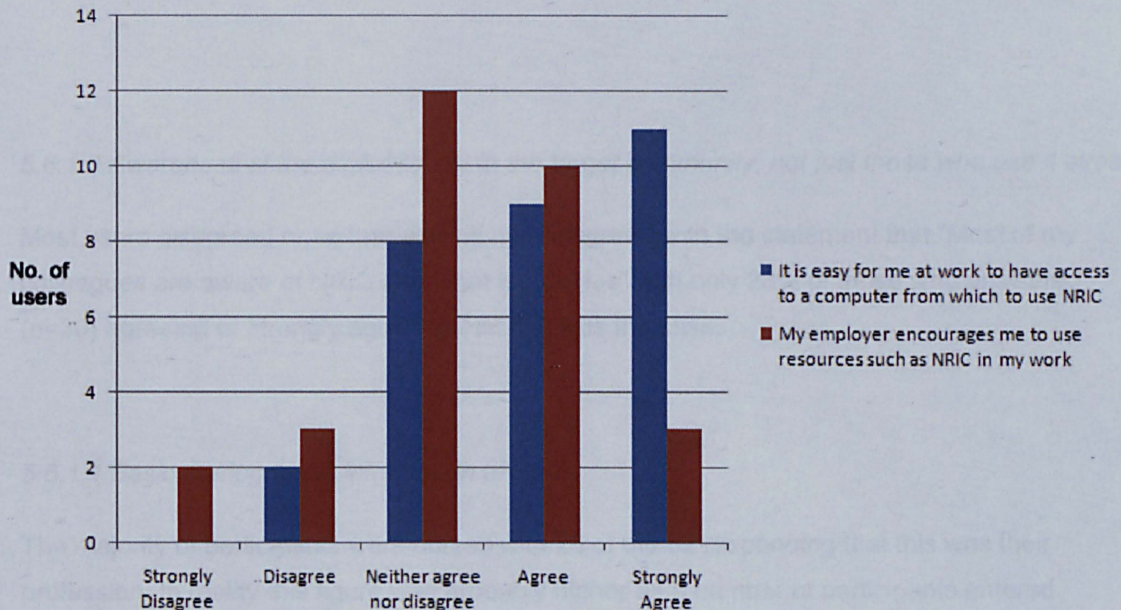


Figure 5.6.1.2 suitability of work environment (N=24 End Questionnaire)

However three interviewees reported distractions in the work environment as a barrier to use:

"....I can be halfway through looking for something and the phone will ring or my bleep will go and then I'll have to go away."

(Interviewee A)

"I probably use it most at home for myself because that's where I tend to do my more concentrated paperwork. The working day is stuffed with distractions."

Interviewee B

"I suppose if my activity's high it might be on the backburner and I need it, I'm always meaning to look at it more than I do"

(Interviewee D)

5.6.1.3 Awareness of the digital library in the target community, not just those who use it already

Most users disagreed or neither agreed nor disagreed with the statement that "Most of my colleagues are aware of NRIC and what it provides" with only 23% of those who answered (n=30) agreeing or strongly agreeing that this was the case.

5.6.1.4 Basic demographic information of users

The majority of participants were nurses with 28 of the 52 responding that this was their profession. In reality this figure was probably higher as a number of participants entered "infection control specialist" or "infection control practitioner" and may well be nurses as well. Other professions included doctors, pharmacists, managers, and microbiologists. Thirty participants were definitely from the UK with 15 unspecified of which the majority were thought to be UK based. Other countries represented included Spain, Saudi Arabia, the UAE and Egypt. The most common highest level of qualification was a taught postgraduate degree and the most frequently stated number of years of experience in their profession was over 20 years

suggesting the study participants were a group of higher level staff who are experienced in their field.

5.6.2. Services

5.6.2.1 User satisfaction with the digital library & how it meets user needs

At the start of the study most users reported the NRIC library to be either very useful (40.4%) or somewhat useful (38.5%) with only two specially reporting that it is not useful. There was no significant change in these results at the end of the study period. In the seventy two visits for which pre and post visit questionnaires were collected users found relevant information in 47 visits (65.3%).

Specific comments included:

"NRIC, um, it's a really good resource"

(Interviewee A)

"I find it a very useful resource"

(Interviewee B)

"Well again it just makes my job easier to do really, I think it makes me, um, it gives me the information I need to perform my role more efficiently."

(Interviewee C)

"It makes a difference if I'm trying to find out what's going on in the NHS"

(Interviewee D)

5.6.2.2 Preferred resources/services already offered by the digital library & awareness of current digital library services and content to existing users

Figure 5.6.2.2 shows the reported use of the different services offered by NRIC as reported by participants answering the end of study questionnaire. These services include the monthly email newsletter, reviewer's assessments of documents within the library, information on conferences and meetings and policy examples and templates. Most users reported to use the services occasionally with lack of awareness being the most common reason for non-use (18.8% of respondents) and only 8% of responses saying they did not find a particular service useful. The most commonly reported use of a service was the reviews of documents which contrasts with the actual use of reviews where the web server logs showed that only 5 of the 48 available reviews for the documents viewed in the 72 visits analysed were actually viewed by users. This conflict in results is perhaps due to a misunderstanding of the terms as each document in the library has an electronic catalogue card with information about the document which also contains an excerpt of a review (if available). Users may have been confusing the catalogue card with the actual review.

The policy templates were noted as useful by two interviewees:

"the policy templates and I find them very useful"

(Interviewee A)

"For instance we haven't got a c.diff policy.....so I've looked on NRIC....it's given me lots of ideas now and I'm actually going to take them forward as examples for other people to read on a working group.....you know sharing information from those that are available on NRIC"

(Interviewee C)

One interviewee mentioned the email alert as being useful:

"if I get the email because we do get emails from NRIC don't we, then I will look at it....it's been the most helpful thing and I would, I would like definitely for that to continue.....it's good on conferences and study days"

(Interviewee D)

And another noted the training events displayed on the home page:

"But NRIC.....the first viewing screen constantly alters and that's a very quick way of just sort of being made aware of anything significant that's come through and the training events can also be interesting it's a way of alerting you to think of something that you might otherwise not have been aware of"

(Interviewee B)

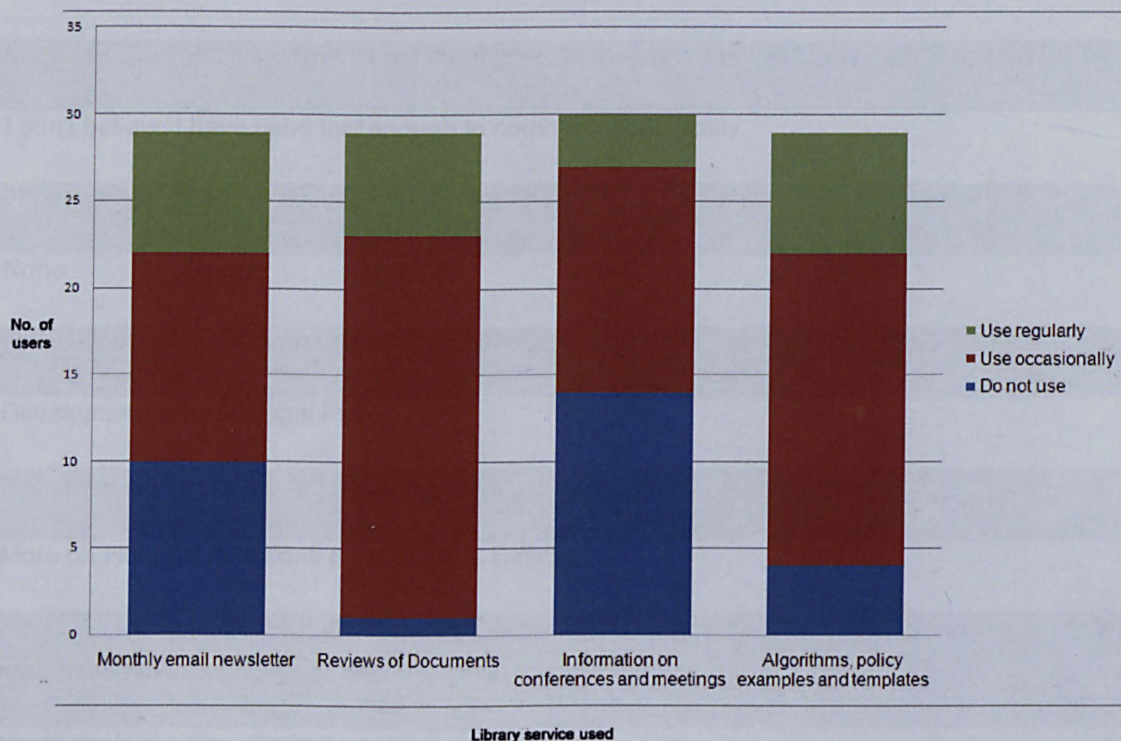


Figure 5.6.2.2 Use of services (End Questionnaire)

5.6.2.3 Gaps in provision

Twenty seven percent of the respondents to the end of study questionnaire felt that access to documents could be improved, particularly the problems of linking through to password protected documents in the Athens system. Three users thought that the policy template section could be enhanced and another three would welcome the opportunity for a discussion board. One felt the library should have a clearer purpose. Twelve users did not respond to any of these questions. Eighty percent of the respondents thought there were few gaps in content of

NRIC, 17% several gaps and only one user thought NRIC had large gaps in coverage. Suggestions for improving content coverage were made in the end of study questionnaire as shown in Table 5.6.2.3.

What areas of content do you feel could be more comprehensive? (N=16)

can't think of any

reviews of clinical practice to aid management of infection in clinical practice

publicise to all in healthcare profession

Specific organisms

More hospital Infection society document links, more journal articles provided/ lit search facility

I don't believe I have used this enough to comment specifically.

Theatres and CSSD endoscopy

None

waste disposal policies and personal protective equipments

Development of a National Policy

I have not identified any.

More on Hospital Infections particularly C Difficile

Provision for non clinical staff who are subject to the same policies/advice in areas like IC. Also more links between research findings and practical applications.

templates/examples of good practice

all areas

Fungal infection, resistances...

Table 5.6.2.3 Suggestions for improvements to content coverage

The interviews also highlighted the desire for a discussion board:

"I wondered about some kind of discussion board on there. Because I know I've had questions I couldn't answer there, you could maybe put them on there so that maybe other folk could see them and answer them."

(Interviewee A)

"is there a, um, not like a chat but a um...a discussion...I think, wasn't there talk that there was going to be one? Yes. So I'd like to get involved in things like that"

(Interviewee C)

Two interviewees discussed the possibility of improving the policy templates and examples:

"NRIC I think could actually be a genuine depository for these documents.....the Department of Health documents alone don't really do it....NRIC could be ensuring that, rather than just offering the policies it should be trying to help people establish better practice in policy writing and perhaps giving the best examples nationally rather than just the examples that are offered."

(Interviewee B)

"I definitely would like model policies not examples of policies because there are actually hundreds of examples of policies and that's not helpful...."

(Interviewee D)

Other topics mentioned were extending the educational focus of NRIC and introducing daily alerts.

"I feel the whole education opportunity is the thing that is missed by NRIC....I would like NRIC to be a one stop resource for free educational materials, to help people privately study the subject....I think the other thing I would like would be to see an extension of the authoritative journal articles....."

(Interviewee B)

"if there could be something on NRIC about what is happening there about these competencies and then is there going to be some sort of generic course that infection control people can sign up to but there, so I suppose it's that decision of whether NRIC could become more active where I think there's a gap"

(Interviewee D)

"having looked at PVL and at that time there wasn't anything on the site that I wasn't already aware of I've become aware of for example, patient information leaflets produced by individual PCTs about PVL so it would be good if there was stuff like that available on the site or some posted on the site"

(Interviewee E)

"I think that would be really good so that when....you're on your email every day, every time something came out there was an alert that would just make you feel more on top of things....you dread things coming out and you not being aware of it"

(Interviewee D)

Other issues that were raised by the interviewees included NRIC being clearer on the origin or nationality coverage of documents, particularly English/Scottish/Welsh documents, and access issues for non-NHS staff to Athens password protected documents.

5.6.3. Technology

5.6.3.1 Basic web access log statistics

Table 5.6.3.1 shows the basic access statistics for the 72 visits to the NRIC library that were analysed by pre and post questionnaires. The average time spent (excluding the time spent completing questionnaires) was quite high being over 12 minutes with one third of users spending over 15 minutes and one third of users spending under 5 minutes in the library. Users were viewing an average of 13 pages per visit and this included 3 documents. However the majority of visits accessed either between 0 and 5 pages (41.7%) or 6 to 10 pages (34.7%). As noted earlier access to the document reviews was low.

Basic access statistics for the 72 visits analysed	
Mean time spent per visit	00:12:22
Mean number different pages viewed per visit	13.74
Mean number of documents viewed per visit	3.07
Median number of documents viewed per visit	2
Total number of reviews available	48
Number of reviews visited	5
% available reviews visited	10.4%

Table 5.6.3.1 Basic access statistics

The independent t-test was performed to show that the more pages a user visited the more likely the library was to have an impact on their knowledge ($p=0.002$), time spent did not influence impact ($p=0.118$) and the more documents a user viewed within the library the more likely NRIC was to have an impact ($p=0.006$).

5.6.3.2 Usability of the digital library

On the whole there is satisfaction with the ease of use the site as shown in Figure 5.6.3.2 and the following comments:

"It is very easy to use and it's easy to get into."

(Interviewee A)

"it's a simple website..., it is a reliable site, you can get straight in there and go straight to mostly the documents you're looking for..."

(Interviewee B)

"I find it very easy to use. When I first got introduced to it my computer skills were not good, they've improved since, they've had to but now I find it a very easy site to use..... very easy to get around...."

(Interviewee C)

"I mean the general design of the site,.....I find very easy, the way the items are listed, the titles of things that makes it easy to find."

(Interviewee E)

There was some issue with the ease of locating documents in NRIC (Figure 5.6.3.2) with several comments about the display of the search results table (Table 5.6.3.2). Seventeen percent felt that the search results table could be improved, specifically to order by date of publication or allow sorting by categories of the user's choice, something supported by data from the interviews:

"the limitations are that the data capture can be far broader than the search terms, than the word terms typed in..... I think a main criticism is that, on the search facility. I know the document that I'm looking for so I come to the site with some knowledge of what the references should be but if for example I typed in aseptic technique some appropriate documents will be electronically trapped by that search word but there will also be a lot of very strange and peripheral documents that actually make for a cluttered and less convincing search."

(Interviewee B)

"when you're going through the research you know when you're looking a subject, it's not always in order of date is it. That would be more useful. Sometimes you know, you've got a 1985 then a 2007 then you've got a 1986. So maybe start off with the newest ones then you can read the ones that are obviously most important first."

(Interviewee C)

"I would like to think that things on the site were in more of a date order...it is the most recent piece of guidance, I would like it to do that"

(Interviewee D)

Another user suggested workshops as a way to train users in navigating NRIC:

"sometimes I think I wish there was a workshop you could go to and say "these are the things I would like NRIC to do" because I always think I'm sure that this is in there somewhere and I think a workshop for people to go to, to actually be talked and walked through the site would be really helpful and for lots of users to share this is what I want to use it for, how can we.... it would help me if somebody did some sort of simple persons guide to it....."

(Interviewee D)

Comments about the search results display and ease of use of the site. What would users like (N=7)

It would be helpful to be able to re-arrange documents in service area into order of date released

more easily searchable tables of info

Topic lists need to be enhanced

ability to arrange documents in each section by date of release before browsing

AS STATED PREVIOUSLY, BETTER MANAGEMENT OF DOCUMENTS E.G. CHRONOLOGICAL ORDER, MADE CLEAR WHEN SUPERCEDED, ETC.

A search facility that sorts documents by date and by author.

easy access

Table 5.6.3.2 Comments about the usability of the library and user preferences

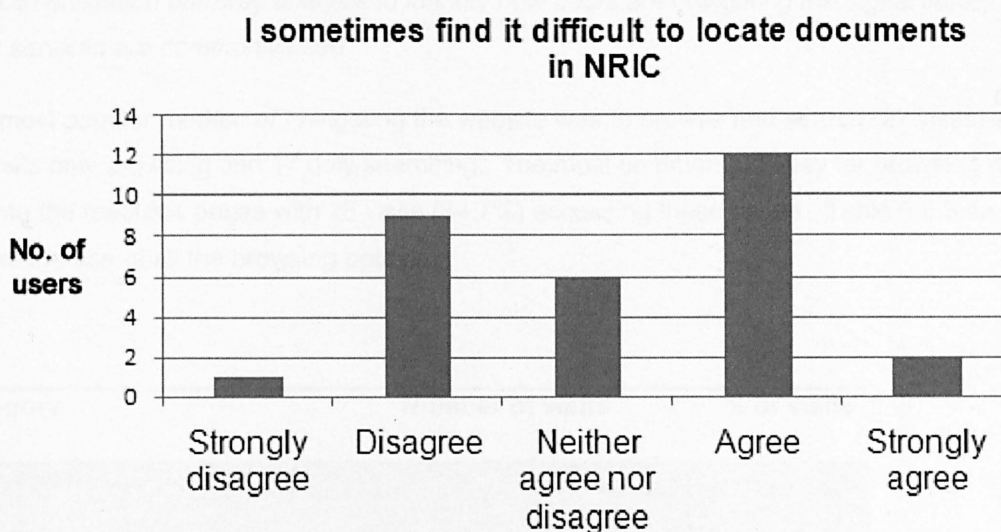


Figure 5.6.3.2 Ease of locating documents in NRIC (N=30 End Questionnaire)

5.6.3.3 Search query analysis i.e. how are people searching the digital library, for what topics/parameters and are they finding what they are looking for

In the 44 visits that used the search facility 88 searches were performed. Only one of these searches used the filtering options provided on the search page to filter by publication type (a review). The most common way to search was to enter a phrase (56.8%) or a single keyword (36.4%) with only four search queries using a Boolean "AND" structure. Table 5.6.3.3 shows what users were searching for. Relevant information was found in 61.4% of visits that searched, however in those that only searched and did not browse to navigate as well (n=17) information was found in only 9 visits (52.9%).

Category of keyword	Number of searches	% of searches
Document/Campaign	9	10.2%
Infection/organism	23	26.1%
Medication/treatment	5	5.7%
Other	9	10.2%
Procedure	15	17.0%
Setting	10	11.4%
Specific item	17	19.3%

Table 5.6.3.3 Search keyword categories

5.6.3.4 Navigation pathway analysis to identify how users are navigating the digital library and what services are commonly used

The most popular method of navigating the website was to browse and search (27 visits) with 24 visits only browsing and 17 only searching. The most common pathway for browsing was to browse the resource pages with 25 visits (34.7%) accessing these pages. Table 5.6.3.4a shows the use of all the browsing options.

Category	Number of visits	% of visits
Browsed Resources	25	34.7%
Browsed Policy	19	26.4%
Browsed Settings	16	22.2%
Browsed Clinical Practice	16	22.2%
Browsed Diseases	13	18.1%
Browsed Transmission	12	16.7%

Table 5.6.3.4a. Popularity of browsing categories

Browsing was more effective than searching in terms of whether or not NRIC had an impact as shown in Table 5.6.3.4b, perhaps due to the issues with the search results display highlighted above.

Category (n=no. users)	Confirmed/strengthened or changed knowledge (n)	Gained knowledge (n)	No impact (n)
Browsed only (24)	45.8% (11)	50.0% (12)	37.5% (9)
Searched only (17)	29.4% (5)	23.5% (4)	52.9% (9)
Browsed and searched (27)	33.3% (9)	37.0% (10)	48.1% (13)

Table 5.6.3.4b Navigation strategy and impact

(note for Table - users may have confirmed knowledge and gained knowledge in the same visit therefore the total of users across each row may be greater than the number of users in each category)

In terms of how people actually use the library within the constraints of the work environment, one interviewee reported that:

“usually what I’ll do is I’ll try and save the documents and then I’ll go back to them. So I hunt out all the different ones and rather reading them at the time I can save them and then go back when I’ve got more time.”

(Interviewee A)

5.6.4. Content

5.6.4.1 Knowledge and attitude changes as a result of using the digital library e.g. actual or self-reported

User knowledge was confirmed, strengthened or changed in 36.1% of visits and knowledge was gained by the user in 37.5% visits. In all there was an impact on user knowledge in 52.8% of the 72 visits. Where knowledge was gained most commonly this was adding to the user’s existing knowledge about their query (20.8% of visits) although on 6 occasions NRIC did add to user knowledge in unrelated areas. Where there was no impact on user knowledge reasons were investigated and are shown in Figure 5.6.4.1.

In the information seeking task there was a correlation between the number of relevant documents viewed and improvements in knowledge with the more documents viewed the greater the number of questions answered correctly although the number of users involved (n=8) was too small for proper analysis.

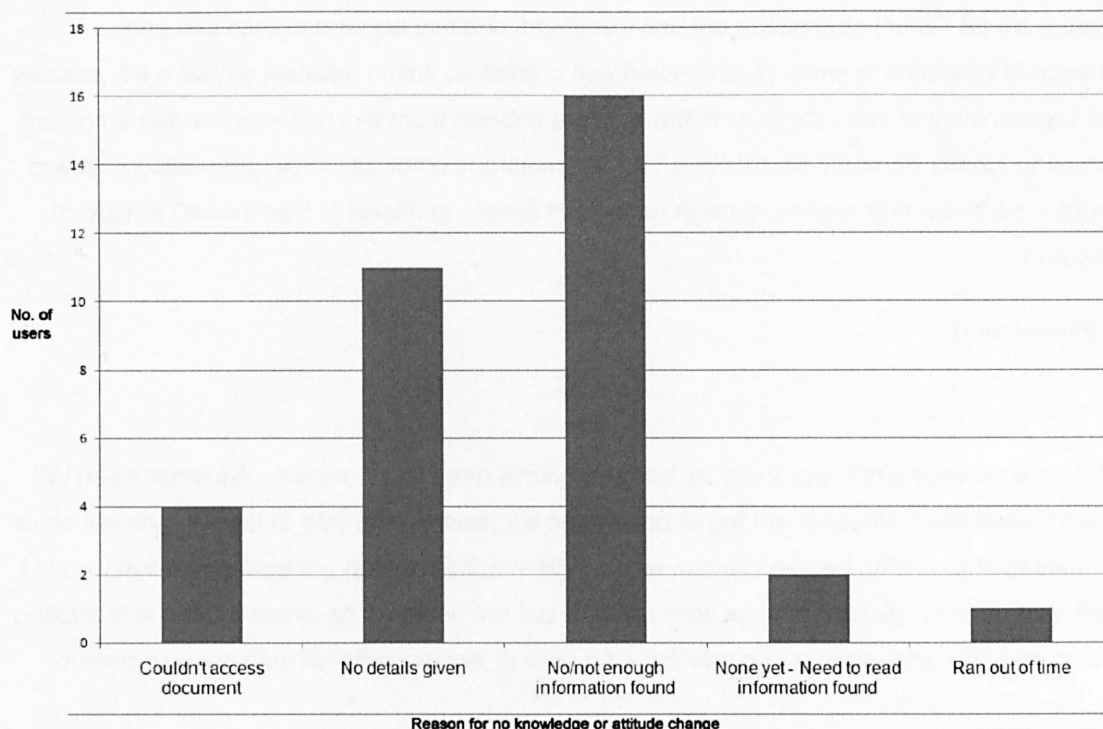


Figure 5.6.4.1 Reasons for lack of impact of NRIC on user knowledge (N=34 Pre and Post Visit questionnaires)

5.6.4.2 The impact of using the digital library on user work e.g. clinical decision-making and patient care, use in creating documents such as policies, guidelines or coursework

Following this case study evaluation an impact score calculation was developed and an impact score calculated for different areas of user work to show how NRIC is having an impact in these areas. Full details of the impact score of NRIC in the different work areas can be found in Section 5.7 where the impact score calculation is described.

Comments from the questionnaires are shown in Table 5.6.4.2 whilst interviewees' comments are shown below.

"actually saved me a lot of time because the resources I need were all in one area. Instead of having to go into Google or whatever and look forever, or go across to the library....so that was good, saved me a lot of time."

(Interviewee A)

"... one can always refer people and say "you'll find the documents there". So it's a useful website, it's a simple website. I think certainly it has helped me in terms of efficiency to speedily find some references when I've most needed them.....within seconds I can find the answer to a question quite easily whereas doing something like a full electronic literature search or wading through a Department of Health or Health Protection Agency website that would be a slower process."

(Interviewee B)

"If I need some information, if I've been writing a report, or you know, I'm preparing something to do training or want to give staff advice, it's been good to get the research base behind me so I know I'm coming from the right direction really.....I've actually printed off a couple of the c.diff policies that are out there, so it's given me lots of ideas now and I'm actually going to take them forward as examples for other people to read on a working group to develop our own policy."

(Interviewee C)

Although NRIC appears to save time, as would be expected, time is also a barrier to use with 5 users reporting that lack of time was a barrier to the benefit of NRIC helping with their work. Navigation and lack of computer access are also barriers for 5 and 2 users respectively.

What impact do you think using NRIC has on your work? Please give examples if available. (N=23)

excellent for finding evidence to base new local policies on
gives good, up to date advice and resources

limited impact prefer using search engines on the Internet which have a major impact on my clinical work
useful tool

Helped me to develop evidence-based policies and patient information sheets - especially in the areas of hand hygiene and Clostridium difficile

Useful one stop resource, but one which could be greatly enhanced and developed

Quick link to topic specific info

Used to get access to some useful documents.

Helpful for up to date info and leads to other sites Used for implementing hand hygiene

able to locate information quickly and all in one place

updating me in with recent information & guidelines which will help in decision making

Has made researching issues far easier

Assisted me finding information on HII re the Scottish site.

ALERTS FROM NEWSLETTER TO NEW GUIDANCE, EVIDENCE, ETC. VERY USEFUL AS ANOTHER WAY TO SEARCH FOR SOMETHING.

It enables me to find the right information and to guide colleagues to this information, e.g. the PCT librarian.

It provides the evidence based information that is required in answering clinical questions. It also alerts users of the Library and within the Trust to the Specialist Library for Infection and they can look also.

Gives me information when I require it

I don't think it has impacted a lot, but if you are not aware of recent guidance it is useful

I am now more aware of its usefulness and expect to use it more in the future

It has been very useful when developing new policies or updating current ones, where i can easily see all current research/evidence base available I have only been in post for 3 years, so initially I used it a lot whenever I was unsure of a particular infection

great impact

I am Infection Control Lead for Medicines Management within PCT. Information obtained from NRIC helps with this role.

In my work as an infectious disease specialist, decisions are always changing, and I use to make some research before taking important decision. NRIC is one of the database in which I usually search

Table 5.6.4.2 Impact of NRIC on user work

5.6.4.3 The dissemination of information found in the digital library to others

Thirteen of the 72 visits were to find information to enable the user to pass on or give advice to other colleagues or patients. One specific visit was purely to find a url link to a Department of Health document for a colleague. In addition users direct others to the NRIC site rather than pass on the information themselves. Three interviewees reported that:

"I find it a very useful resource, in as much that it's a one stop direction that I can give to colleagues, to students so that they can perhaps easily find the key references. It's easier, than to say, direct them to the Department of Health which is a very big website and is perhaps less likely to give them a successful experience."

(Interviewee B)

"...I've recommended it to my colleagues as well".

(Interviewee A)

...very often later on when I'm with staff ... they will tell me they've found something on NRIC even though I know I've told them about it but they've gone to NRIC and found it themselves and I think that probably makes it a bit more meaningful than me just trolling it out to them. So I think it is a useful resource for me to give to staff, clinical staff I think have used it quite a lot"

(Interviewee D)

5.6.5 Summary of results of NRIC impact evaluation

To summarise the results of this impact evaluation and show how the Impact-ED model can be used to create a short impact summary the following text was created by writing short key points for each criteria and combining the key points for each criteria in each dimension into one paragraph.

5.6.5.1 How is NRIC used in the community? (Community dimension of model)

NRIC is used mostly for finding evidence to support policy development, to implement a change in practice at work or for personal education. In addition a significant number of visitors use NRIC to search for “what’s new”. NRIC is often used in preference to source websites but the awareness of NRIC in the user community could be improved.

5.6.5.2 How well received is NRIC and its services? (Services dimension of model)

NRIC is generally perceived to be a useful resource and provided relevant information in over 65% of visits. However awareness of all services but particularly the monthly newsletter and training courses/conferences information could be improved. A regularly updated home page is important for attracting users. Clarification is required about the purpose of the document reviews (Reviewer’s Assessments) as compared with the electronic catalogue card for each document. Coverage of NRIC is generally perceived to be good with few gaps in content. Popular suggestions for development include adding a discussion board and developing the template policy section into national model policies. Another suggestion was that NRIC could allow users to select the frequency of email alerts for new documents rather than just offer a monthly email. Access to external documents can cause problems for some users.

5.6.5.3 Usability and navigation (Technology dimension of model)

The users in this study spend a significant amount of time per visit (average over 12 minutes) and visit on average 3 documents in one session. But only 10.4% of available document reviews are accessed. NRIC is generally perceived as an easy to use website but the main issue is with the display of the search results which are currently not ordered by date. It was suggested that workshops could be run to increase awareness of NRIC and help users navigate it more effectively. In terms of getting around the library browsing is more common than searching and when NRIC is browsed rather than searched it is more likely to have an impact on user knowledge.

5.6.5.4 NRIC’s impact (Content dimension of model)

NRIC had an impact on user knowledge in 52.8% of visits. The main reasons for no impact were that not enough information was found or the user could not access the document. NRIC has a positive impact in many areas of user work including policy development, training and education, implementing changes in practice and business case or proposal preparation. A significant proportion of NRIC use is to find information either on behalf of someone else or to pass information/advice on to patients or colleagues and users also direct others to NRIC to find information themselves.

5.7 Developing an impact score calculation

Following this analysis an Impact score calculation was developed. The aim of this was to allow consistent comparison of digital library impact over time and potentially across libraries. The impact score was developed in three stages, firstly to create a score that is a function of the impact a library has on user knowledge as related to the number of visits it receives, secondly to calculate an impact score related to reasons for use and the output of the knowledge change or gain and thirdly to identify how that score can be improved and the potential maximum impact score that could be achieved by the library.

5.7.1 The initial impact score (I)

The first score is essentially a ratio. Data was obtained from the pre and post visit questionnaires and coded to show where there was a strengthening of knowledge or change in knowledge or gain in knowledge as a result of a visit to the library. For each visit where this occurred the library scored 1. A running total was kept until all visits had been scored and this was then divided by the total number of visits analysed. In the case of the NRIC library there were 38 visits where a strengthening, change or gain in knowledge was reported and a total of 72 visits therefore the first score was 0.53. The calculation is shown below:

V_t = total number of visits analysed

K = knowledge score (where K= sum of number of visits where either a change/strengthening or gain in knowledge is recorded)

$$\text{Impact score (I)} = K/V_t$$

So in the case of NRIC

$$V_t = 72$$

$$K = 38$$

$$I = 38 \div 72 = 0.53$$

There can be a maximum score of 1 where all visits would result in a change/strengthening or gain in knowledge.

5.7.2 The impact score related to reason for use or outputs (I_o)

The next step is to integrate the data regarding the context in which the library is being used and the impact it is having on user work i.e. the reason for use. All the visits were coded according to the reason for visiting or intended use/output of the information/knowledge gained. This then allows an impact score to be calculated for each output to show in which areas of user work the library has the most impact. Outputs are specific to each library and can be specified by the evaluator as a result of the data collection by identifying potential outputs of digital library use and categorising them. The impact score is calculated in the same way as above with the difference being that only the visits that are coded with each output are included in the corresponding output impact score. So the calculation is as follows:

Output 1 (O_1) = e.g. Policy and guidance writing

Output 2 (O_2) = e.g. Passing information or giving advice to others

O_3 etc...

V_{Ox} = Number of visits coded with O_x

K_{Ox} = Number of visits coded with O_x with a recorded change/strengthening or gain in knowledge

$$I_{Ox} = K_{Ox} \div V_{Ox}$$

So in the case of the NRIC library the impact score for Outputs were as follows:

O_1 = Advice/information for colleagues/patients

$V_{O1} = 13$

$K_{O1} = 7$

$$I_{O1} = 7 \div 13 = 0.54$$

O_2 = Business case/grant/bid/proposal writing

$$V_{O_2} = 3$$

$$K_{O_2} = 2$$

$$I_{O_2} = 2+3 = 0.67$$

O_3 = Implement change in practice at work

$$V_{O_3} = 10$$

$$K_{O_3} = 6$$

$$I_{O_3} = 6+10 = 0.60$$

O_4 = Personal education

$$V_{O_4} = 14$$

$$K_{O_4} = 7$$

$$I_{O_4} = 7+14 = 0.50$$

O_5 = Policy and guidance writing

$$V_{O_5} = 12$$

$$K_{O_5} = 7$$

$$I_{O_5} = 7+12 = 0.58$$

O_6 = Training/education of other staff

$$V_{O_6} = 11$$

$$K_{O_6} = 6$$

$$I_{O_6} = 6+11 = 0.55$$

5.7.3 The maximum potential impact score ($I_{\max}$)

A key feature of the Impact-ED model and the digital library impact evaluation put forward in this thesis is the ability to see where the impact of the library can be improved as a part of formative evaluation. No impact evaluation can score an impact score of 1 as there will be reasons for the library having no impact on user knowledge during a visit over which it has no control e.g. user's poor Internet connection causing time out, interruption to the users visit by something or someone external to the library. Therefore by recording reasons given by users where the library has no impact on user knowledge it is possible to predict a known maximum achievable score based on the areas in which the library has control. That is if a reason for no impact is that the user could not find any information related to their query then the impact score could have been improved by either adding information where it was lacking or by improving the navigation or organisation of the library so the available information is more easily found. The calculation is as follows:

Reason for no impact 1 (R_1) = e.g. No relevant information found

Reason for no impact 2 (R_2) = e.g. Couldn't access document

R_3 etc

V_{Rx} = total number of visits with no impact coded R_x

Known maximum achievable impact score ($I_{\max}$) = $((\text{Sum of all } V_{Rx})/V_t) + 1$

Therefore the actual impact score (I_A) can be calculated as a ratio with the $I_{\max}$ as follows:

$$I_A = I + I_{\max}$$

So in the case of the NRIC library the reasons for no impact that could be influenced by the library were:

R_1 = No. of users who couldn't access document

R_2 = No. of users who reported no/not enough relevant information found

$V_{R1} = 4$

$V_{R2} = 16$

$$I_{\max} = ((4+16)/72) + 0.53 = 0.28 + 0.5$$

$$I_{\max} = 0.81$$

Therefore the highest known achievable impact score for the NRIC library is 0.81. Using this figure the I_A is:

$$I_A = 0.53 + 0.81$$

$$I_A = 0.65$$

The I_A can also be calculated for all outputs rather than just an overall figure as follows:

5.7.3.1 Output 1 – Advice/information for colleagues/patients

V_{R1O1} = No. of visits with no impact for output 1 and recorded reason 1 = 2

V_{R2O1} = No. of visits with no impact for output 1 and recorded reason 2 = 3

$V_{O1} = 13$

$$I_{O1\max} = ((V_{R1O1}+V_{R2O1}) + V_{O1}) + I_{O1} = ((2+3) + 13) + 0.54 = 0.38 + 0.54$$

$$I_{O1\max} = 0.92$$

$$I_{AO1} = 0.54 + 0.92 = 0.58$$

5.7.3.2 Output 2 – Business case/grant/bid/proposal writing

$$V_{R1O2} = 0$$

$$V_{R2O2} = 0$$

Because both R_{1O2} and R_{2O2} were zero no I_{O2max} could be calculated therefore I_{O2} remains the most accurate measure.

5.7.3.3 Output 3 – Implement change in practice at work

$$V_{R1O3} = 0$$

$$V_{R2O3} = 2$$

$$V_{O3} = 10$$

$$I_{O3max} = (V_{R1O3} + V_{R2O3}) + V_{O3} + I_{O3} = ((0+2) + 10) + 0.60 = 0.20 + 0.60$$

$$I_{O3max} = 0.80$$

$$I_{AO3} = 0.60 + 0.80 = 0.75$$

5.7.3.4 Output 4 – Personal education

$$V_{R1O4} = 0$$

$$V_{R2O4} = 3$$

$$V_{O4} = 14$$

$$I_{O4max} = (V_{R1O4} + V_{R2O4}) + V_{O4} + I_{O4} = ((0+3) + 14) + 0.5 = 0.21 + 0.50$$

$$I_{O4max} = 0.71$$

$$I_{AO4} = 0.50 + 0.71 = 0.70$$

5.7.3.5 Output 5 – Policy and guidance development

$$V_{R1O5} = 1$$

$$V_{R2O4} = 2$$

$$V_{O5} = 12$$

$$I_{O5max} = ((V_{R1O5} + V_{R2O5}) + V_{O5}) + I_{O5} = ((1+2) + 12) + 0.58 = 0.25 + 0.58$$

$$I_{O5max} = 0.83$$

$$I_{AO5} = 0.58 + 0.83 = 0.70$$

5.7.3.6 Output 6 – Training and education of other staff

$$V_{R1O6} = 0$$

$$V_{R2O6} = 2$$

$$V_{O6} = 11$$

$$I_{O6max} = ((V_{R1O6} + V_{R2O6}) + V_{O6}) + I_{O6} = ((0+2) + 11) + 0.55 = 0.18 + 0.55$$

$$I_{O6max} = 0.73$$

$$I_{AO6} = 0.55 + 0.73 = 0.75$$

Figure 5.7.3 shows the impact scores for all outputs. The I_{max} score represents the maximum known achievable impact score based on recorded reasons for visits with no impact. The I_A score represents the actual impact achieved assuming that a positive impact could only have been achieved in those visits where no impact was recorded and reasons were within the control of the library. The I score represents the actual impact achieved assuming that a positive impact on knowledge could have been achieved in all visits to the library regardless of the reason recorded for no impact. Therefore the true impact score will lie somewhere between the I_A and the I scores assuming that there will be some visits to the library that result in no impact that could, were the library improved, result in an impact next time, and some visits to the library that improvements to the library would have no influence over such as interruptions to library use by external factors. Where no I_{max} could be calculated due to a lack of recorded reasons for no impact during a visit the value of 1 was assumed and therefore the I_A will equal the I in these instances.

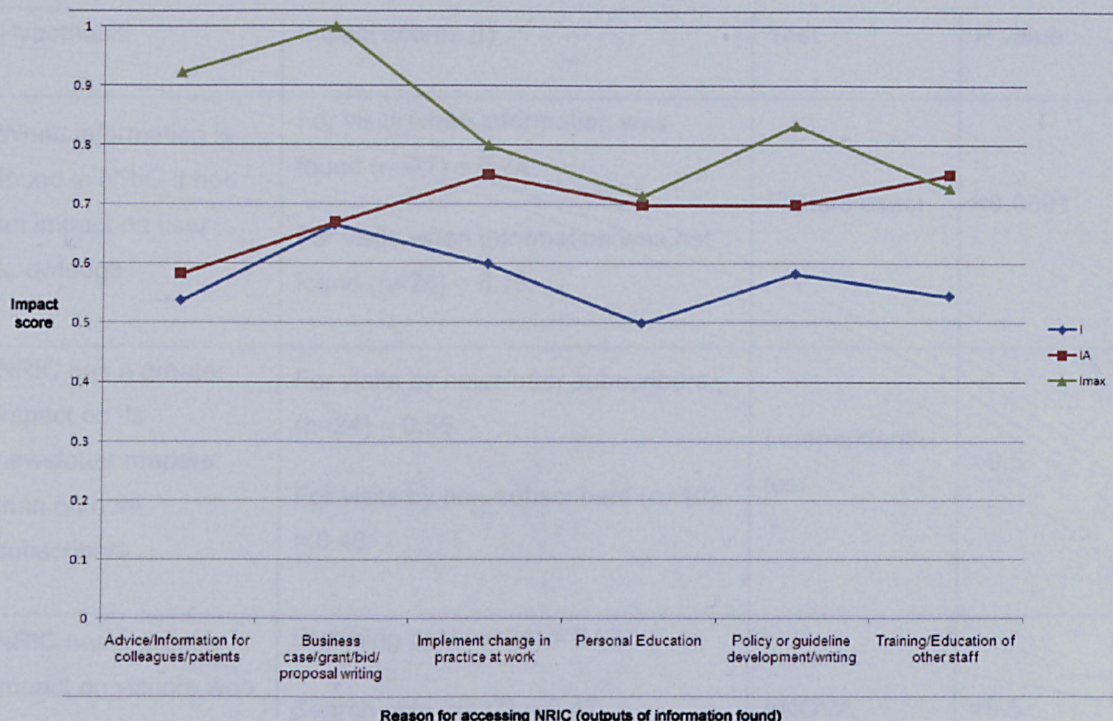


Figure 5.7.3 Impact scores for all outputs for the NRIC library

5.7.4 Using impact scores to generate hypotheses

In order to meet requirement IV described in Section 2.3.4 where it is stated that a digital library impact evaluation should identify what library services and features influence impact and where a library could be improved the impact score calculation can be used to generate hypotheses that can then be validated by statistical tests. Data was collected for the following library features and services:

- Whether or not NRIC provided relevant information to the users query
- Whether or not users subscribed to the NRIC newsletter
- What navigation strategy users chose
- Whether users viewed the library's reviewer's assessments

Calculating impact scores for these different groups resulted in the hypotheses shown in table 5.7.4. Statistical tests were performed to validate the data. The Kolmogorov-Smirnov test determined that the data was normally distributed.

Hypothesis	Impact scores (I)	Test	P value
When information is found in NRIC it has an impact on user knowledge	For visits when information was found (n=47) = 0.74 For visits when information was not found (n=24) = 0.13	Fishers exact	<0.0001
NRIC has a greater impact on its newsletter readers than on non-subscribers	For visits by newsletter subscribers (n=24) = 0.55 For visits by non-subscribers (n=10) = 0.48	Independent t-test	>0.5
NRIC has a greater impact on visitors who browse rather than search or do both	Browsing only (n=24) = 0.63 Search only (n=17) = 0.47 Browse and search (n=27) = 0.52	ANOVA	>0.5
NRIC has a greater impact on visitors who view reviewer's assessments than those who don't	View reviewer's assessments (n=5) = 0.6 Didn't view reviewer's assessments (n=29) = 0.52	Independent t-test	>0.5

Table 5.7.4 Statistical significance of the impact of NRIC services and features

The table shows that if people find related information in NRIC then this does have an impact on their knowledge. However there was no statistical significance for any of the other hypotheses despite the differences in impact scores. This is possibly due to the small sample numbers involved and a larger evaluation may provide more significant results. It does suggest that in the short term the single most important thing the NRIC library could do would be to improve its content coverage as there were a substantial number of visits (24 out of 72) where relevant information was not found by the user and should this be improved the impact score of NRIC would improve significantly. Suggestions for improvement in content coverage were made by users and are presented in Section 5.6.2.3.

5.7.5 Benefits and weaknesses of the impact score as a measurement of impact

The actual impact score (I_A) is an indicative measure of impact and can be a useful comparison for a library to measure its impact over time or potentially for comparison between libraries. It can provide a single figure to show impact on user knowledge and is simple to calculate from data collected from a digital library impact evaluation using the Impact-ED model. However the weaknesses of the score are as follows:

- The I_A may overestimate the impact of the library as it excludes visits for which there is no information whilst the initial impact score (I) underestimates the impact as it includes these visits. Therefore the true impact score lies somewhere between these two figures so it is perhaps better to quote both as a minimum and maximum impact score.
- The simplicity of the score calculation does not take into account users' experience of the library or demographics; however, this could be considered irrelevant as an ideal library would have an impact on its users without knowing who or where they are or how many times they have visited before.
- The measure of whether or not the library had an impact on user knowledge is binary and does not grade knowledge gain/change in anyway. Although this is not 100% accurate it would be impossible from the data gained to objectively grade knowledge when users are not answering set questions to which there are known correct answers. The impact score provides the best alternative possible within the constraints of the evaluation study.
- The estimation of the maximum known achievable score is dependent on user reporting of why the library had no impact on their knowledge which as shown in the case study is not always consistent with 11 of the 34 visits with no impact providing no details. Therefore these were excluded from the I_{max} . This leads to slight overestimation of the impact score as discussed above.
- The generation of hypotheses by calculating impact scores for users of different services and features of the library compared with users who do not use these services allows testing for statistical significance to see which services and features are related to the impact of the library. This shows where the library can improve. A problem can occur where sample numbers are small and significance tests are more likely to return results as being insignificant. However when they can be used these tests are useful for suggesting relationships between features in the library and impact.

Therefore, despite its limitations, the impact score does provide some quantification of the impact of a digital library and is available for librarians to calculate themselves as part of an evaluation using the Impact-ED model.

5.8 Summary

This chapter has presented the results of the implementation of the Impact-ED model, described how an impact score can be calculated from the data and how this can be validated by statistical tests. It concludes with a discussion of the benefits and weaknesses of the impact score calculation. The key points of this chapter are:

- The NRIC library was shown to have an impact in 52.8% of visits and the number of pages viewed and number of documents viewed both influenced the impact
- An impact score calculation was developed to show:
 - The overall impact of the library for all recorded visits (I)
 - The impact of the library in relation to different outputs of the information sought (I_o)
 - The maximum potential impact of the library in relation to the reasons for visits where it had no impact but where it had potential to improve its impact (I_{max})
 - The actual impact of the library as a ratio of I_{max} (I_A)
 - The I_A of the NRIC library was 0.58
- Statistical tests were performed to determine which services and features of the library may influence its impact and showed that the only significant factor in whether or not the NRIC library had an impact was whether or not users found relevant information.

The next chapter discusses how the model was refined as a result of this implementation, its limitations and potential future work.

6. Discussion

6.1 Introduction

This chapter describes how the model and framework was refined following the testing on the NRIC library. It goes on to discuss some of the limitations of the research and finally present ideas for future work and research that could result from the development of this model.

6.2 Refining the model

As result of the implementation the model was re-examined and refined accordingly. The changes were as follows:

- The learning exercise/information seeking task did not have a good response in the NRIC evaluation and did not provide any data that added value to that obtained by other methods. In fact this method of data collection was contrary to the requirements that specify that the evaluation should be a real world evaluation with real users with their own information needs rather than creating a scenario for users to complete. It is possible also that adding this method to the framework created an additional burden on the user, requiring them to complete a task that was in addition to their normal use of the library which may account for the lack of response. Therefore this method was removed from the framework.
- The questionnaire and interview templates were adapted to make them suitable for libraries from all domains not just medical digital libraries i.e. library specific information was removed and the templates made non-domain specific.

The refined Impact-ED model is shown in Figure 6.2a and the refined framework in Figure 6.2b. Templates can be found in Appendix 1.

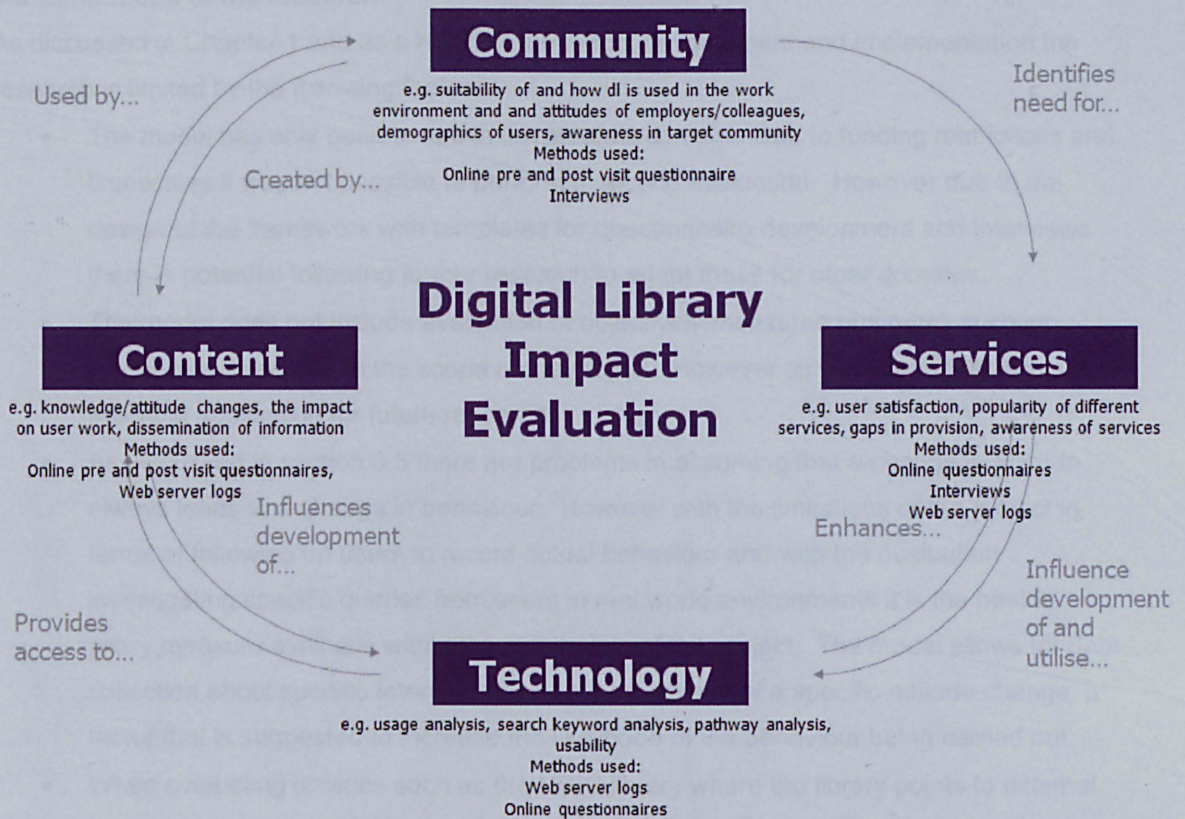


Figure 6.2a The refined Impact-ED model

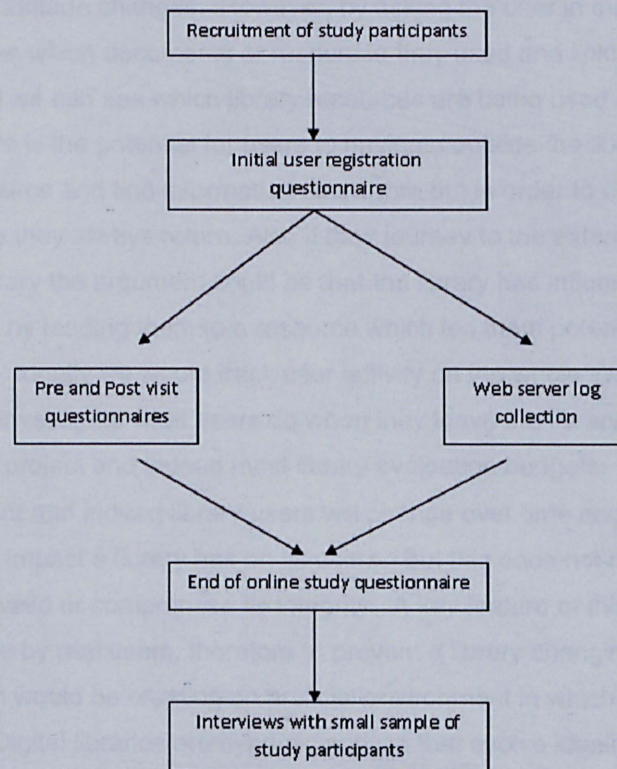


Figure 6.2b Refined framework of methods

6.3 Limitations of the research

As discussed in Chapter 1 and as a result of the model development and implementation the research is limited by the following factors:

- The model has only been tested in the medical domain. Due to funding restrictions and timescales it was not possible to perform a second evaluation. However due to the design of the framework with templates for questionnaire development and interviews there is potential following further research to adapt these for other domains.
- The model does not include evaluation of objectively measured outcomes such as prescribing rates due to the scope of the project. However as discussed below this is a potential application for future research.
- As discussed in section 3.5 there are problems in assuming that a change in attitude always leads to a change in behaviour. However with the limitations of the project in terms of following up users to record actual behaviour and with the evaluation investigating specific queries from users in real world environments it is the best fit proxy measure available within the constraints of the project. The model allows for data collection about specific intended behaviour as a result of a specific attitude change, a factor that is suggested to increase the likelihood of the behaviour being carried out.
- When evaluating libraries such as the NRIC library where the library points to external content rather than providing content itself, it is more difficult to track user activity and relate that to attitude changes. However, by asking the user in the post visit questionnaires which documents or resources they used and linking this to catalogue cards viewed we can see which library resources are being used and their relation to impact. There is the potential for users to navigate outside the library once on an external resource and find information elsewhere but in order to complete the questionnaire they always return. Also if their journey to the external information began inside the library the argument could be that the library has influenced their knowledge and attitudes by leading them to a resource which led them potentially elsewhere to their answer. Ideally we would track user activity on the whole World Wide Web during a session to investigate what users do when they leave the library but this is outside the scope of this project and indeed most library evaluation budgets.
- Library content and indeed library users will change over time and both of these could influence the impact a library has on its users. But this does not make the impact evaluation invalid or compromise its integrity. A key feature of this model is to evaluate real world use by real users, therefore to prevent a library changing during the course of an evaluation would be creating an artificial environment in which the evaluation is performed. Digital libraries are dynamic entities that evolve ideally in-line with user needs and this will be a never-ending process as users come and go with different needs at different times. The impact score provides a measurement of the impact of a library for a given period of time. If appropriate this period of time can be broken down into smaller periods and impact across the study period be compared. Knowledge

about users collected from the online questionnaires and also from other sources such as target user groups (in NRIC's case the Infection Control Professionals) to compare changes in these groups with changes in the impact. The dynamic nature of both the digital library and its user group simply provides more potential for research and investigation into what influences library impact rather than invalidating results.

- The measurement of the impact of the library on user knowledge does not grade knowledge but records a binary result. This is due to the difficulty of objectively grading user knowledge both before and after library use about a non-standardised topic or question. As discussed in the previous chapter setting specific questions or tasks compromises the integrity of the evaluation as the users are not visiting with their own information needs. Therefore recording knowledge as a binary result is a valid compromise that allows evaluation in a real-world setting.
- Small sample numbers can result in insignificant statistical test results despite variations in the impact score. This cannot be overcome other than by re-performing the study with larger sample sizes but in real-world evaluations it is not always possible to recruit large enough samples. Therefore in some evaluations decisions about future library development to improve impact may have to be made on the basis of the data without statistical support.
- The model does rely on users completing the questionnaires at the point of library use so there is the risk that for some visits, perhaps where they are pressed for time, users ignore these questionnaires and data is lost. However in the NRIC study there were only four out of 72 visits where users did not complete a post use questionnaire. It is possible that there were instances where users visited the library but did not login and therefore did not complete a pre use questionnaire but there is little that can be done about this except to regularly encourage the users to login and participate when visiting the library.
- The model does not allow for full investigation of the potential impact a digital library could have on members of its target population who do not currently use the library. Therefore the model as tested on the NRIC library is only evaluating the impact on existing users rather than on the user base as a whole. This obviously will result in a higher impact than if the total user base were targeted. However this is outside the scope of this project as the aim is to investigate the impact the library currently has and how it can be improved to increase the impact it has when people visit it not how to increase awareness, however valid that may be as a separate avenue of research.
- Little exploration of user characteristics is undertaken in this research due to the small numbers of participants. However data is collected in the questionnaires and can be used in larger studies to explore relationships between user demographics and library impact.

Despite the limitations described above, this project has added value to the research literature around digital library evaluation and as discussed in the previous chapter met the aims and objectives of the research. The next section discusses how the model and framework could potentially be developed in future work.

6.4 Potential for further development

The model has great potential for further work. The two most obvious developments are to test the model in another domain such as business or law to test its applicability in these fields. There is no reason to suggest there would be any major differences in the application of the model. However further research would be prudent & interesting for developments in digital library impact evaluation research, particularly in terms of promoting the model to practitioners in the digital library community. The model is intended to be able to be used by digital library developers and digital librarians therefore to have these professionals running an evaluation rather than researchers would help to ensure the model is suitably adaptable by its target users.

Secondly it would be valuable to extend the model to record objectively measured outcomes. In the medical domain this could be performed in a controlled setting such as a GP surgery where the impact of access to a library on prescribing rates or patient-doctor consultation outcome could be evaluated. Either patient use in the waiting room or GP use in the consultation could be evaluated and data collected from medical records or prescription records.

It would also be valuable to repeat the application of the model on the NRIC library at a later date to compare the impact following improvements made as a result of the initial implementation of the Impact-ED model. Particularly evaluating the content coverage and whether a larger number of visits result in relevant information being found and the effect this has on the library impact. Additionally the providers of the NRIC library also developed and maintain several other medical libraries and performing a digital library impact evaluation using the Impact-ED model on each library could provide useful data about which libraries perform best in terms of their impact, what services and features from different libraries are related to impact. This could potentially lead to a template for future new digital library development to be produced that describes how to create a digital library to maximise its impact.

Additionally another area of relevant research is the Evidence Based Librarianship movement in which library practices are based on evidence and research combined with working experiences. Evidence is graded into levels so that the best available evidence can be found on which to base actions and decisions. The emphasis is however on relevance to librarianship rather than rigour (Eldredge 2000) and the importance of the clarity of the question being asked is noted by researchers in the field. (Oxman & Guyatt 1988). This movement started in healthcare librarianship following the Evidence Based Medicine movement that has been key in trying to improve access to knowledge in healthcare and medicine, summarised succinctly by

Gray and Brice (2003) as "Knowledge is the enemy of disease". The applicability of this research to evaluating digital library impact could come in investigating barriers to users acting on evidence despite changes in knowledge and attitude. This would be a "next step" following implementation of an impact evaluation model and is beyond the scope of this research which investigates barriers to knowledge and attitude changes but is well worth bearing in mind for future work.

There is also the potential to explore the application of the model to new web technologies where users can learn from and support each other via suitable tools that are not yet available on the NRIC digital library such as discussion forums, user resource rating scales, and social networking tools that may be incorporated into digital libraries in the future or to which digital libraries may be applied.

There are therefore several avenues of potential future research that have resulted from this thesis. The next chapter discusses the value of the research and how well it meets the aims and objectives outlined in Chapter 1.

Chapter 7 – Conclusion

In any research project it is important to ensure that the research undertaken meets the requirements of the project and the aims and objectives. Initially this chapter discusses the value of the research to the digital library research domain, how well the model and framework meet the requirements presented in Section 2.3.4 and concludes by discussing how well the project meets the aims and objectives presented in Chapter 1.

7.1 The value of the research (i.e. the contribution to the domain)

This research has added value to the digital library research domain as follows:

- It has identified a gap in previous research where there was limited digital library impact evaluation (Chapter 2). It found that there was no quantification of digital library impact (apart from in one study where an estimation of time saved was made), that no attempt was made to identify relationships between library features and services and library impact and that few evaluations have been performed on real users in real-world settings at the time of library use (most relied on user recall of previous use – see Chapter 2).
- It developed a set of requirements for digital library impact evaluation which take into account definitions of impact in a digital library context.
- It has developed a model for digital library impact evaluation (Chapter 3) that can be applied to any digital library in any domain. The model is based around the four dimensions of digital library work identified by Fox & Marchionini (Fox & Marchionini 1999) in order to ensure that any evaluation reflects what a digital library is and does. The model includes criteria collated from previous digital library impact evaluations that were grouped into the digital library dimensions and improved to reflect the digital library impact evaluation requirements.
- It has produced a framework for performing a digital library impact evaluation that describes the process of the evaluation and includes data collection templates for ease of use.
- It has utilised robust research methods that have been widely used in evaluation research and combined data from these methods to provide a novel approach to impact evaluation
- This novel approach includes:
 - the linkage of data from questionnaires, interviews and web server logs on an individual user basis
 - the calculation of an impact score for the library overall and as related to user work
 - the generation of hypotheses for features or services of the library from the impact score that may influence impact that are then tested for statistical significance

- The model provides templates that can be adapted for use by library developers and providers

The research will be published in the library and information science domain and the health informatics domain so that results can be disseminated to the wider research community. A report has been written and distributed to NRIC Advisory Board members and placed on the NRIC website. A link to this report was emailed to all participants and NRIC mailing list members.

7.2 Did the model meet the requirements?

The previous chapters have presented a literature review to identify a need for a digital library impact evaluation model, suggested requirements for an ideal evaluation (Chapter 2) and then described the development (Chapter 3) and implementation (Chapter 5) of such a model that aims to meet these requirements. An estimation of how well the model does this was provided in Chapter 3 but following implementation on the NRIC library (Chapter 5) an accurate representation of this can now be made. Table 7.2 shows how the Impact-ED model evaluation compares with the evaluations reviewed in Chapter 2 and shows that it is the only evaluation that meets all the requirements. The points below describe in detail how it meets these requirements.

- I. Identify the effect or impression of the digital library on the user and their work – data was obtained from the registration and end questionnaires and the pre and post visit questionnaires as users were given the opportunity to describe how the library has an impact on their work at the point of visit and also in retrospect in general terms as described in the criteria for the community, services and content dimensions. In the NRIC evaluation it was found that the library was an integral part of some user's work and has an impact in several areas of user work. The model and framework therefore enabled the collection of data to meet this requirement.
- II. Identify the short and long-term changes the library makes to the user and their work – repeating the application of the model to several impact studies over time will enable the impact of a library to be compared over time by providing a consistent impact factor for comparison and also allow users to report how their use of the library has changed them and their work over time. The pre and post visit questionnaires show how a visit to the library changes knowledge and attitudes in the short term. In the NRIC evaluation short term changes in knowledge and intended application of this knowledge to the users' role were identified. In addition quotes from the interviews supported the idea that digital resources such as NRIC had changed the way people worked. Repetition of this study in a few months time would allow identification of longer term changes to user work. Therefore despite the constraints of project funding and timescales meaning that in the NRIC evaluation it was not possible to identify long-term

changes the model and framework have met this requirement as a repeat evaluation would provide the data required.

- III. How the library is being used to help the user in their work – the pre and post visit and registration and study end questionnaires and interviews all provide data that meets this requirement. In the NRIC evaluation several reasons for use of the library were identified, along with the type of information sought and how users intended to use the information found. Therefore the model and framework meet this requirement.
- IV. The relationship between library features and services and the library impact and how they can be improved to increase impact – the web server logs and questionnaires provide data that can be linked to show how library features and services can be improved to increase the library impact. The impact score calculation identifies those instances where information is not found so here the library could improve its impact by improving its coverage of certain subject areas. In addition the NRIC evaluation showed that visits that browsed were more likely to have an impact than those that searched. Therefore the model and framework meet this requirement.
- V. Real-time evaluation – the pre and post visit questionnaires capture data at the point of library use, not relying on recall of users of previous visits meeting this requirement.
- VI. Real-world evaluation – the framework is designed to be used in a real-world setting i.e. on an active or live digital library in the user's domain and not in a laboratory style or simulated setting. The evaluation of the NRIC library was a real-world evaluation showing that the model and framework can be used in this setting and meet this requirement.
- VII. Real users – the framework was implemented with actual library users with their own information needs taking part and the methods were all applied remotely with the exception of the face to face interview with a small sample of users. The model and framework therefore also meet this requirement.
- VIII. Quantification of the impact – an impact score was developed to meet this requirement (Chapter 5).

As described above the model and framework have met the requirements for digital library evaluation as presented in Section 2.3.4.

	CIAP	CLINT	Cochrane	CAR	Fed e-Sci	Forest	MDConsult	NASA ADS	OLEH	OTSeeker	Perseus	SHELSI	SWICE	Toronto	VIVOS	Stoloff	Impact-ED
I. Identify the effect or impression of the digital library on the user and their work	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
II. Identify the short and long-term changes the library makes to the user and their work	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
III. Identify how the library is being used to help the user in their work	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IV. Identify the relationship between library features and services and the library impact and how they can be improved to increase impact	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes
V. Measure real-time use	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No	No	No	No	Yes
VI. Measure real-world use	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VII. Evaluate real users	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VIII. Produce a quantifiable impact score	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No	No	No	No	Yes

Table 7.2 How does the model compare to the previous evaluations from Chapter 3

7.3 Did the research meet the research aim & objectives?

The model and framework have been shown to meet the requirements for digital library impact evaluation but has the research project met the original aim and objectives presented in Chapter 1? A full discussion follows. The research aim was:

To identify the need for and develop a model and framework for digital library impact evaluation, that when applied will show the impact of a digital library on its user community. To include developing a general methodology for impact evaluation across library sectors, enable tailoring of the framework by its users to evaluate the impact of the digital library on knowledge and intended behaviour/decision changes, investigating the barriers to use of the digital library to gain an awareness of how the library can be improved to increase its impact.

The research has developed a framework that provides a general methodology for impact evaluation that is not specific to one library sector but could be applied to any digital library. It has provided templates that can be adapted by users to suit their evaluation requirements and their libraries to evaluate knowledge and intended behaviour or decision changes as shown in the implementation of the model on the NRIC library. The impact score calculation uses the reported barriers to use and application of the digital library to user work to determine where the impact of the library can be increased by improving the library features and services.

The framework uses a range of methods to collect data to provide a wide picture of the impact of a library specifically the impact on different areas of user work and how the library can be improved to increase its impact. The design of the framework with templates for questionnaire development and interviews should be easy to follow and as these templates are non-subject specific there is potential following further research to adapt these for other domains, particularly within the healthcare sector.

Therefore the aim of the research was met by this project. The aim was supported by a set of objectives that describe practically how the aim would be achieved. These were:

- I. Review the literature to identify the current status of impact evaluation research in digital libraries
- II. Identify a need for a digital library impact evaluation model and identify requirements for digital library impact evaluation
- III. Develop a model and framework for digital library impact evaluation with a method of producing an impact score
- IV. Implement the model and framework on a case study digital library

- V. Evaluate the model and framework in terms of the how well it meets the requirements for a digital library impact evaluation and refine as necessary
- VI. Identify how the model can be developed in future research

Objectives I & II were met by the literature review in chapter 2 which presented the current state of digital library impact evaluation research and showed how this research fails to meet with the requirements for digital library impact evaluation. Chapter 3 presents the Impact-ED model and framework and shows stages of development up to implementation partially meeting objective III. Objective IV is met by Chapter 5 as it describes how the model was tested on the NRIC library. This chapter also shows the development of an impact score calculation to complete the requirement in objective III. The next objective (V) was met earlier in this chapter where the model was compared to the requirements for digital library evaluation and refined as a result of the NRIC evaluation. Finally objective VI is met in the previous chapter where a full discussion of how the model can be developed in future research projects is found.

7.4 Summary

This chapter has shown that the research has provided added value to the digital library research domain by identifying and filling a gap in impact evaluation research. The requirements for digital library impact evaluation were met by the model and framework that were developed as part of the project and the aims and objectives were met by the research. The Impact-ED model and framework is the product of this research that can be applied by evaluators to digital libraries to evaluate their impact and identify areas in which the library can be improved.

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Appendix 1 – Template Questionnaires

Registration Questionnaire for the {INSERT LIBRARY NAME} Evaluation

Please fill in the following questionnaire answering each question as fully as you feel able. There are no right or wrong answers. The aim of this questionnaire is to gain an understanding of how much and why you use {INSERT LIBRARY NAME} and the impact this has on your work. When you have finished completing the questionnaire please click the "SUBMIT" button at the bottom of the page.

Many thanks for your participation in this study.

YOUR NAME

INSTITUTION/LIBRARY NAME

1. Please enter your

Name:

Job Title: *Free text box*

Current Profession (e.g. Nurse, Microbiologist, Lawyer): *Free text box*

The county you work in (If not UK enter country): *Free text box*

Do you ever use a shared computer for accessing {INSERT LIBRARY NAME}? Yes/No *Radio button*

Where did you hear about this evaluation? *Free text box*

2. What is your highest level qualification?

Multiple choice (select one only)

GCSEs or equivalent (school study to age 16)

A Levels or equivalent (school study to age 18)

Diploma (e.g. BTEC, HND or NVQ)

Undergraduate degree (e.g. BSc, BA)

Taught Postgraduate degree (e.g. MSc, MA)

Research Postgraduate degree (e.g. PhD)

3. How many years experience do you have in your current profession? (Not just your current post)

Multiple choice (select one only)

0-5 years

6-10 years

11-15 years

16-20 years

21 + years

4. Where do you source the best available evidence for your work, when needed? Please specify sources.

Free text box

5. For what reasons do you use the Internet at work? Please select all that apply.

Multiple choice (select all that apply)

Personal study/research/continuing education

Local policy and/or local guideline development

To provide evidence to support decision-making

To provide information for bid/proposal or grant preparation

To find information to pass on to others (colleagues, customers, patients etc)

To find information about meetings and conferences

Please specify any reasons not listed above
Free text box

6. On average, how often do you use the {INSERT LIBRARY NAME}?

Multiple choice (select one only)

Daily

More than once a week but not as often as daily

Once a week

More than once a month but not as often as once a week

Once a month

Less than once a month

7. For what reasons have you used {INSERT LIBRARY NAME}? Please select all that apply.

Multiple choice (select all that apply)

Personal study/research/continuing education

Local policy and/or local guideline development

To provide evidence to support decision-making

To provide information for bid/proposal or grant preparation

To find information to pass on to others (colleagues, customers, patients etc)

To find information about meetings and conferences

I have not used {INSERT LIBRARY NAME} before this evaluation

Please specify any reasons not listed above

Free text box

8. How useful do you find {INSERT LIBRARY NAME}?

Multiple choice (select one only)

Very useful – provides me with relevant information regularly

Somewhat useful – provides me with relevant information occasionally

Not very useful – provides me with relevant information rarely

9. What impact does {INSERT LIBRARY NAME} have on your work? Please select all that apply.

Multiple choice (select all that apply)

Contributed directly to decisions about patient care/case development/projects

Been used in policy making &/or guideline development

Helped improve my professional knowledge

Helped in training/education of other staff/colleagues

I have not used {INSERT LIBRARY NAME} before this evaluation

Please specify any impacts not listed above

Free text box

10. What does {INSERT LIBRARY NAME} not provide that you would find useful?

Free text box

Before you visit {INSERT LIBRARY NAME}.....

Thank you for logging in to {INSERT LIBRARY NAME} today. If you are using {INSERT LIBRARY NAME} to look for evidence/information for your work then please fill in the following 3 questions before you visit {INSERT LIBRARY NAME}, answering each question as fully as you feel able. There are no right or wrong answers. The aim of this questionnaire is to gain an understanding of what your knowledge and attitudes are before using {INSERT LIBRARY NAME}. You will also be asked to complete a short questionnaire when you have finished using {INSERT LIBRARY NAME}. This is very important as without this post-use questionnaire we cannot evaluate whether {INSERT LIBRARY NAME} is having any impact on your work so

please do complete this. When you have finished completing this questionnaire please click the "SUBMIT" button at the bottom of the page and this will take you to NRIC. If you are not using {INSERT LIBRARY NAME} to find evidence/information for your work please go straight to the {INSERT LIBRARY NAME} home page.

Many thanks again for your participation in this study.

YOUR NAME
INSTITUTION/LIBRARY NAME

1. What information are you hoping to find during your visit to {INSERT LIBRARY NAME}?

Free text box

2. Before searching {INSERT LIBRARY NAME}, do you have any knowledge or attitudes, or conclusions about the information you are trying to find? If yes, what are they and what has led you to them?

Free text box

3. Does having this knowledge/attitude impact your role at work in any way? How?

Free text box

Template Post Visit Questionnaire

1. First go to the {INSERT LIBRARY NAME} home page..... {INSERT LIBRARY URL}

2. Then before you leave.....

Before you leave {INSERT LIBRARY NAME}, if you have not already done so, please now complete the following questions. This is very important as without this post-use questionnaire we cannot evaluate whether {INSERT LIBRARY NAME} is having any impact on your work and subsequently find out how to make it more useful to you, so please do complete this. When you have finished completing this questionnaire please click the "SUBMIT" button at the bottom of the page. If you have already completed this questionnaire during this visit please logout here.

Many thanks again for your participation in this study.

{INSERT YOUR NAME}
{INSERT YOUR INSTITUTION/LIBRARY}

1. Now that you have visited {INSERT LIBRARY NAME}, has your knowledge/attitude been:

a. confirmed

Multiple choice (select one only)

Yes

No

If yes, how?

Free text box

b.strengthened

Multiple choice (select one only)

Yes

No

If yes, how?
Free text box

c. changed
Multiple choice (select one only)
Yes
No

If yes, how?
Free text box

d. eliminated?
Multiple choice (select one only)
Yes
No

If yes, how?
Free text box

What impact do you think this will have on your work?
Free text box

2a. After visiting NRIC, have you gained any new knowledge, attitudes, or conclusions about your query?
Multiple choice (select one only)
Yes
No

2b. If yes, please describe them.
Free text box

2c. What document(s) in {INSERT LIBRARY NAME} led you to these new Knowledge/attitudes/conclusions?
Free text box

2d. What impact do you think these new knowledge/attitudes/conclusions are going to have on your work?
Free text box

End of Study Questionnaire for the {INSERT LIBRARY NAME} Evaluation

Please fill in the following questionnaire answering each question as fully as you feel able. There are no right or wrong answers. The aim of this questionnaire is to gain an understanding of how much and why you used {INSERT LIBRARY NAME} during the study period and the impact this has had on your work. When you have finished completing the questionnaire please click the "SUBMIT" button at the bottom of the page.

Many thanks for your participation in this study.

YOUR NAME
INSTITUTION/LIBRARY NAME

1. Please enter your name
Free text box

2. For what reasons do you use the Internet at work? Please select all that apply.

Multiple choice (select all that apply)

Multiple choice (select all that apply)

Personal study/research/continuing education

Local policy and/or local guideline development

To provide evidence to support decision-making

To provide information for bid/proposal or grant preparation

To find information to pass on to others (colleagues, customers, patients etc)

To find information about meetings and conferences

Please specify any reasons not listed above

Free text box

3. On average, during the study period, how often have you used {INSERT LIBRARY NAME}?

Multiple choice (select one only)

Daily

More than once a week but not as often as daily

Once a week

More than once a month but not as often as once a week

Once a month

Less than once a month

4. For what reasons have you used {INSERT LIBRARY NAME} during the study period?

Please select all that apply.

Multiple choice (select all that apply)

Personal study/research/continuing education

Local policy and/or local guideline development

To provide evidence to support decision-making

To provide information for bid/proposal or grant preparation

To find information to pass on to others (colleagues, customers, patients etc)

To find information about meetings and conferences

I have not used {INSERT LIBRARY NAME} during this evaluation

Please specify any reasons not listed above

Free text box

5. How useful have you found {INSERT LIBRARY NAME} during the study period?

Multiple choice (select one only)

Very useful – provides me with relevant information regularly

Somewhat useful – provides me with relevant information occasionally

Not very useful – provides me with relevant information rarely

6. Please rank your agreement with the following statements:

6a. It is easy for me at work to have access to a computer from which to use {INSERT LIBRARY NAME}

Multiple choice (select one only)

Strongly Agree

Agree

Neither agree nor disagree

Disagree

Strongly disagree

6b. My employer encourages me to use resources such as {INSERT LIBRARY NAME} in my work

Multiple choice (select one only)

Strongly Agree

Agree

Neither agree nor disagree

Disagree

Strongly disagree

6c. I prefer browsing {INSERT LIBRARY NAME} to using the search box

Multiple choice (select one only)

Strongly Agree

Agree

Neither agree nor disagree

Disagree

Strongly disagree

6d. I sometimes find it difficult to locate documents in {INSERT LIBRARY NAME}

Multiple choice (select one only)

Strongly Agree

Agree

Neither agree nor disagree

Disagree

Strongly disagree

6e. Most of my colleagues are aware of {INSERT LIBRARY NAME} & what it provides

Multiple choice (select one only)

Strongly Agree

Agree

Neither agree nor disagree

Disagree

Strongly disagree

7. Please describe anything else that prevents you from using {INSERT LIBRARY NAME} successfully in your work.

Free text box

8. Please describe anything else that helps you to use {INSERT LIBRARY NAME} successfully in your work.

Free text box

9. What impact do you think using {INSERT LIBRARY NAME} has on your work? Please give examples if available.

Free text box

10. What services available in {INSERT LIBRARY NAME} have you used?

10a. {INSERT SERVICE}

Multiple choice (select one only)

Use regularly

Use occasionally

Do not use

If not why not?

Multiple choice (select one only)

I don't find it useful

I was not aware of this service

{CONTINUE WITH 10b 10c ETC FOR FURTHER SERVICES}

11. What other services would you like {INSERT LIBRARY NAME} to provide?

Free text box

12. How well do you think {INSERT LIBRARY NAME} covers the {INSERT LIBRARY DOMAIN E.G. INFECTION CONTROL, EMPLOYMENT LAW ETC} domain?

Multiple choice (select one only)

Few gaps in content

Several gaps in content

Large gaps in content

13. What areas of content do you feel could be more comprehensive?

Free text box

14. Please provide any further information about features you would like to see on {INSERT LIBRARY NAME} & things you would like changed

Free text box

15. Would you be interested in registering to use {INSERT LIBRARY NAME} (for free) so that it could be personalised to your needs?

Multiple choice (select one only)

Yes

No

16. Please comment on your experience of the evaluation study e.g. about what was expected of you as a participant, ease of completing questionnaires etc

Free text box

17. Would you be willing to be interviewed about your use of {INSERT LIBRARY NAME} during the study period? The interviewer will travel to you & it will take approximately 1 hour

Multiple choice (select one only)

Yes

No

Appendix 2 – Learning Exercise/ Information Seeking Task Questionnaire

NRIC Information Seeking Task Questionnaire

Thank you for taking part in this learning exercise. You will now be asked to complete some questions and then to browse the nric website. You will then be asked to complete the questions again. The second questionnaire (a repeat of the first) is very important so please complete this. The aim of these questionnaires is to see whether or not the website is changing your knowledge or attitudes to particular topics. Firstly please answer the questions below. Please remember this is not about how clever you are but about how well the website provides you with useful information so please answer honestly! You will not be linked to your answers in any publication of data.

Many thanks again for your participation in this study.

Gemma Madle
City University

1. In November 2007 the Department of Health published an Essence of Care Environmental tool for measuring indicators of best practice. Two factors within this benchmarking tool focus on cleanliness and infection control.

1a. What do you feel are the most important indicators of best practice to ensure that "People experience care in a consistently clean environment"? Please enter up to three indicators.

3 x Free text box

1b. What do you feel are the most important indicators of best practice to ensure that "People feel confident that infection control precautions are in place? Please enter up to three indicators.

3 x Free text box

1c. How important do you feel it is for infection control teams to be involved in new builds and refurbishments as early in the planning as possible?

Multiple choice (select one only)

Essential

Very important

Quite important

Not particularly important

Unnecessary

2. In 2007 several reports were published regarding the outbreak of *c.difficile* in Kent Hospitals. In particular the Healthcare Commission was asked to identify lessons learned and provide recommendations for future practice in healthcare institutions.

2a. Which groups are more at risk of contracting *c.difficile* in hospital? Please list up to six.

6 x Free text box

2b. My trust complies with current guidelines for reporting *c.difficile* cases

Strongly agree

Agree

Neither agree nor disagree

Disagree

Strongly disagree

2c. I am aware of the recent changes introduced earlier this year by the Department of Health to the reporting of *c.difficile* to the Health Protection Agency

Multiple choice (select one only)

Yes

No

If yes, please state one change introduced.
Free text box

2d. Please rank the following lessons learned following the investigation of the outbreak in Maidstone & Tunbridge Wells NHS Trust in order of importance, 1 being the most important and 6 the least. Please only use each number once i.e. all numbers should be used if you rank all 6 statements. If you don't think a statement is important leave it out.

- A. Infection control needs to be an integral part of clinical governance & a high priority across the trust
- B. Ward cleanliness, spaces between beds, and disposal or decontamination of dirty equipment is key in controlling an outbreak
- C. Regular monitoring of patients with c.difficile is essential
- D. Antibiotic prescribing must follow good practice and antibiotics must be of the narrowest possible spectrum and of the shortest possible period.
- E. Accurate reporting of cases is necessary
- F. The trust needs to ensure effective isolation for those patients who pose a potential or actual high risk of infection to others.

Appendix 3 – Interview Template

Sense-making interview template

Aims of interviews:

1. To identify how participants saw their situation by describing their emotions and feelings, and the ways in which they were challenged by the situation;
2. To describe the perceived gaps participants had to overcome to be able to find the information they were looking for;
3. To identify the impact of the information, gained from NRIC, in helping (or hindering) the participants to resolve their situation.

Adapted from:

Dervin, Brenda and anonymous students (1997). A study of user sense-making of new communication technologies, past and present: The Sense-Making instrument with sample interviews. [On-line]. Available: <http://communication.sbs.ohio-state.edu/sense-making/inst/idervin97tech.html>

Template:

First introduce research, NRIC, recap what they've done so far, the aim of the research and confidentiality of interview.

1. Can you tell me a little bit about your role as a "(profession)"
- 2.a What does NRIC mean to you? (Examples: NRIC is a key part of my work and I consult it frequently, NRIC is a resource I find useful when I use but I do not regard it as a key part of my work)
- 2.b What leads you to say that....how does it connect with your work? (Examples: I use the monthly update emails to keep myself up to date with current policy and guidance)
3. What was it that led you to use NRIC? What happened -- what happened first, second, and so on? (Examples; I saw NRIC demonstrated at a conference, I was told about it by someone else)

4. Where and when do you use NRIC? (E.g. at work, at home, during my shift, off duty etc)

5. Did any barriers or constraints stand in the way of your use of NRIC?

5.1. What barriers or constraints stood in way? (Examples: Lack of computer access, lack of time, difficulty using the site – check questionnaire responses etc)

List:

5.2. For each: How did it stand in the way? How did it hinder you?

5.3. For each: How did this hindrance connect to your work?

5.4 For each: Were you able to overcome this barrier or constraint? If so, how? If not, why not? (e.g. refining search technique)

6. Did anything facilitate or help your use of NRIC?

6.1. What facilitated or helped? (E.g. receiving the monthly newsletter, the reviewer's assessments)

List:

6.2. For each: How did it help or facilitate your use of NRIC?

6.3. For each: How did this help connect to your work?

7. Looking back over your uses of NRIC, what have been the big questions or confusions you have faced in using it?

7.1. What were these? (E.g. how could I be integrating this resource into my daily practice? Are the reviewer's assessments reliable?)

List:

7.2: For each: how did this question relate to your work?

7.3. For each: did you get a complete answer? partial? no answer at all?

7.4: For each: If not a complete answer: what stood in way?

7.5: For each: Did asking this question impact or change you and/or your work? how?

8. Looking back over your uses of NRIC, what have been the emotions or feelings you have had in connection with its use?

8.1. What were these? (E.g. satisfaction at finding something useful, frustration at difficulty using NRIC or not finding what I need)

List:

8.2: For each: how did this emotion/feeling relate to your life?

8.3: For each: Did the emotion/feeling impact or change you or your work? how? (Positive feeling can motivate, negative can de-motivate and reduce likelihood of using it again)

9. Looking back over your uses of NRIC, did you come to new ideas or conclusions in the process of using it?

9.1. What were these? (E.g. new knowledge or attitudes)

List:

9.2: For each: how did this idea relate to your work?

9.3: For each: Did this idea impact or change you or your work in any way? how?

10. Looking over your uses of NRIC, name any ways in which it has impacted your work in good ways, in ways that were helpful or facilitating?

10.1. Ways NRIC has helped? (With policy making, treatment decisions etc, improve personal knowledge)

List:

10.2. For each: How did this help connect with your work?

10.3: For each: Did this impact or change you or your work in any way? how?

11. Looking back over your uses of NRIC, name any ways in which it has impacted your work in bad ways, in ways that were hindering?

11.1. Ways NRIC has hindered? (takes time to use, provided too much information)

List:

- 11.2. For each: How did this hindrance connect with your work?
11.3. For each: Did this impact or change you in any way? how?

Round up – thanks for taking part, check they've said all they want to say. Anonymity.
Summary of all research will be sent out by newsletter email later in year.

Appendix 4 - Coding sheet for pre and post visit questionnaire data

Questionnaire data			
Information need	Qualitative answer to be grouped later		
Is the answer available in NRIC	Yes/No		
If Yes, where?	Document name		
Existing knowledge	Yes - extensive	Yes - some	Yes - no detail given
Does this knowledge impact role?	Yes/No		No
Expected impact	Qualitative answer to be grouped later		
Knowledge confirmed	Yes/No		
Knowledge strengthened	Yes/No		
Knowledge changed	Yes/No		
Knowledge eliminated	Yes/No		
No information found	True/False		
In what way?	Qualitative answer to be grouped later		
Expected impact of this knowledge	Yes/No		
Expected impact of this knowledge	Qualitative answer to be grouped later		
Knowledge gained	Yes	No	Unknown
Knowledge gained	Qualitative answer to be grouped later	Describe how user gained or did not gain knowledge e.g. found new document or found unrelated documents that led to knowledge gain in different area or not yet gained knowledge because needs to read documents	No
Connection to work	Qualitative answer to be grouped later		
Documents 1	String		
Documents 2	String		
Documents 3	String		
Documents 4	String		
Expected impact new knowledge	Qualitative answer to be grouped later		

Log data

Time spent	hh:mm:ss	
No. page visits (excl questionnaire & login pages)	Integer	
No. different pages visited (excl questionnaire & login pages)	Integer	
Browsed	Yes/No	
Topics browsed 1	NRIC Topic pages browsed	
Topics browsed 2	NRIC Topic pages browsed	
Topics browsed 3	NRIC Topic pages browsed	
Topics browsed 4	NRIC Topic pages browsed	
Searched	Number of searches performed	
Keywords used	Search string	
Keywords used 2	Search string	
Keywords used 3	Search string	
Keywords used 4	Search string	
Viewed documents	Yes/No	
Viewed appropriate documents	Yes/No	I.e. documents related to their query
Viewed Reviewer's assessment	Yes/No	
Documents viewed 1	Document title	
Documents viewed 2	Document title	
Documents viewed 3	Document title	
Documents viewed 4	Document title	
Visited NeLI	Yes/No	
Visited TII	Yes/No	
Visited Bugs & Drugs	Yes/No	

Appendix 5 – Recruitment Email for the NRIC Evaluation

At NRIC we believe it is important to know whether you are using NRIC to help in your everyday work, why you are using it & whether you find it easy to use and what makes it difficult to use. We want NRIC to have an impact on your work by helping you to find relevant information when you need it. The only way to know if this is the case or not is to ask you! Take part in our NRIC evaluation for your chance to win as well as your chance to let us know what you think about NRIC and the impact it has on your work. Please contact Gemma Madle at g.c.madle@city.ac.uk for details of how to take part. More information can be found below.

Kind regards

The NRIC Team

More details of the NRIC Evaluation Study:

What does it involve?

We don't simply want to ask a few quick questions and get basic and not very useful answers. We believe that proper evaluation is necessary to gain a good understanding of how you use NRIC & how you would like it to be in order to develop it further and make it more useful to you. So we are looking for people to sign up to a 3 month study. It will not take a great deal of your time over this period but the 3 month length is necessary for us to evaluate use over time and gain a better picture than could be achieved in a shorter study. Your involvement will be as follows:

1. Registration – we will send you a registration username and password and whenever you access NRIC during the 3 month study period we ask that you login so we are able to see when you are accessing the website. All accesses will be confidential and all data anonymised so you will not be linked to your access. You will

also be asked to complete a short questionnaire to find out how often you have used NRIC and your reasons for doing so. This should take no longer than 10 minutes to complete.

2. Pre and post use questionnaires – when you login to NRIC during the study period to search for evidence or information for your work you will be asked to answer 3 questions about your reason for visiting and your existing knowledge around this area. When you leave NRIC at the end of this session you will be asked to complete a further 5 questions asking you how your knowledge/attitudes have changed and which documents you found useful. You will be asked to do this at least twice during the study period. These questionnaires should add no more than 10 minutes to your visit time.

3. In the middle of the study period you will be asked to set 15/20 minutes aside to complete two questionnaires. You will first be asked some questions about your knowledge of and attitudes to infection control and then asked to browse the NRIC website. Finally you will be asked to complete another questionnaire about infection control! This should take no longer than 20 minutes in total (unless you wish to spend longer!)

4. At the end of the 3 month study period you will be sent a short questionnaire asking about your use of NRIC during the study period. This questionnaire should take no longer than 15 minutes to complete.

5. We will also be looking for people who are willing to be interviewed about their use of NRIC. This will take approximately 1 hour and the interviewer will travel to you. This part of the study is optional as only a few interviews are necessary.

What do I do next?

Please contact Gemma Madle at g.c.madle@city.ac.uk if you wish to take part in this study. There will be a draw to win £100 Amazon or M&S vouchers for all those who take part.

Impact-ED - A New Model of Digital Library Impact Evaluation

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Abstract. This paper presents Impact-ED, a new model for digital library impact evaluation. The model draws on assumptions from the Theory of Planned Behaviour and the Sense-Making Model. The paper discusses the current shortfalls of digital library impact evaluation and presents an alternative. Knowledge and attitude are put forward as potential measures of impact and different methods are triangulated and data linked to provide a comprehensive picture of the impact of the library at the time of use. The model shows how the digital library is being used to benefit users in their work, how it is changing their knowledge and attitudes and how the information found is used in real-time in the real world. It is being tested in the healthcare domain on the National Resource for Infection Control (www.nric.org.uk) but is expected to be transferable to other domains as further work will prove.

Keywords. Digital Library Evaluation; Sense-making; Knowledge and Attitudes; Impact Evaluation

1. Introduction

Recent years have seen an explosion in the amount of money being spent on IT projects in healthcare [1,2]. Digital libraries have the potential to change working culture creating new types of professional relationships and communities based across distances, hierarchy and other traditional barriers. With this huge investment of public money it is surely important to investigate these changes and the impact of the resources provided on clinical care, decision-making and patient outcomes.

But what do we mean by impact and how can we measure it? Previous research in the 1980s and early 1990s has shown that physical hospital library services can contribute to patient care and clinical decision-making [3-5]. In one study Medline searches performed earlier in the patient's hospital stay were associated with lower costs, charges and length of stay than those whose searches were performed later [6]. There have been several papers discussing the impact of healthcare libraries, both physical and digital [4;7-10] and a systematic review of the effectiveness of traditional libraries and clinical librarian programs on patient care [11] but development of methodologies is lacking. A recent systematic review of evaluations of the impact of healthcare digital libraries identified a need for new methodologies with most previous evaluations measuring impact with questionnaires and interviews, therefore relying on self-reported impact [12]. A healthcare digital library impact evaluation needs to show how the digital library is being used to benefit users in their work, how it is changing their knowledge and attitudes and how the information found is used. It needs to evaluate at the time of use not just retrospectively and activity within the library should be monitored. So far research has failed to achieve this [12].

This paper attempts to address this need by using the Theory of Planned Behaviour and Dervin's Sense-making model to develop and present a new model for digital library impact evaluation research based on knowledge and attitude change.

2. The Impact-ED Model

Fox and Marchionini [13] presented a model of digital library dimensions in 1999 based on the research in the field at that time. They suggested there are four dimensions to DL work: Community; Services; Technology; Content. DL impact evaluation should be measuring the impact of DL content, provided through the technology and services, on its community. Is use of the DL changing a clinician's work practice rather than just helping them on one or two occasions? Evaluation of DL impact should involve investigation into the longer-term effects on the user rather than just short-term changes in decision-making.

The requirements of a DL Impact Evaluation Model are set out below as they apply to each dimension of the DL. The aim of developing the model in this way was to ensure that evaluation is based around the function and purpose of a digital library as well as the community that it serves. The requirements were compiled following a review of the literature to identify impact evaluations of healthcare digital libraries and are published elsewhere[12]. In summary the ideal evaluation will not just evaluate self-reported knowledge, attitude and behaviour changes but actual changes, and changes that occur as a result of real-time, real use in the real world by real users. Data should be obtained from different methods and linked for individual users to obtain a more in-depth picture of digital library use and impact. The review of the literature [12] identified 12 healthcare DL evaluations (2 of the same DL). Only one of the studies evaluated real-time use of the DL at the point of need in the user's work and none linked data on an individual basis from different sources. Therefore a new model is required that meets these requirements and provides a template for implementing DL impact evaluations. Figure 1 shows the model.

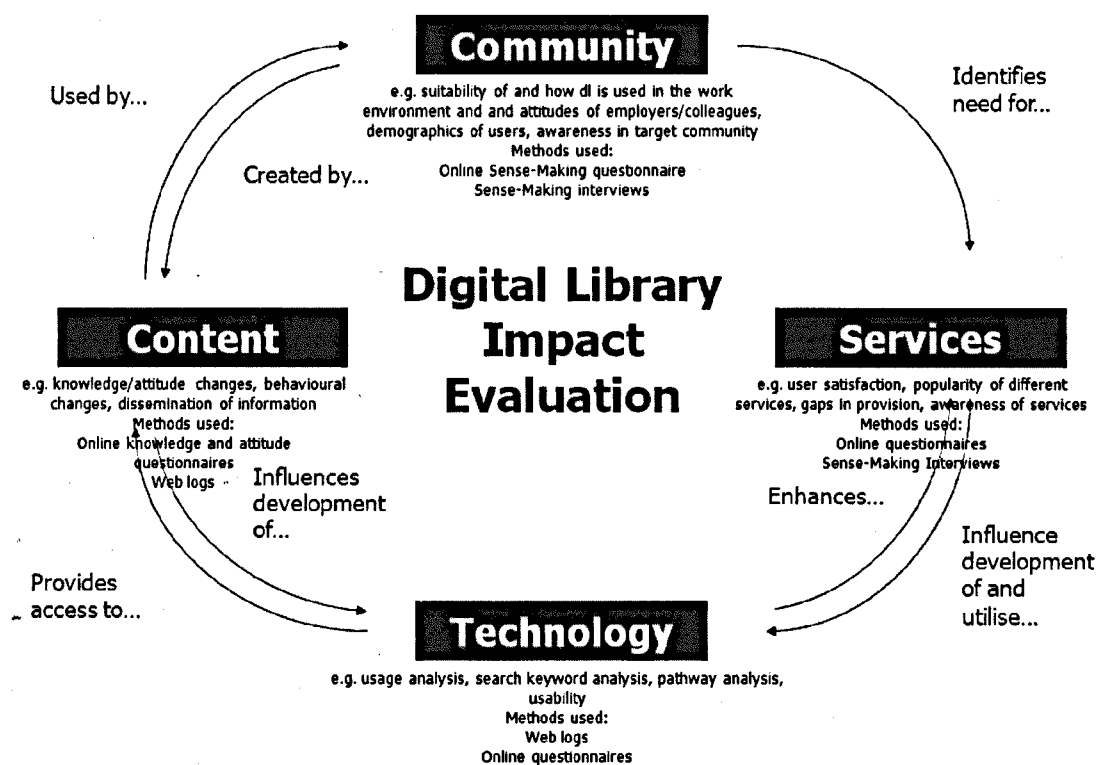


Fig. 1. The Impact-ED model

The intention of the Impact-ED (**I**mpact **E**valuation for **D**igital **L**ibraries) model is that a variety of methods are used to collect data and data is linked to provide a more rounded picture of a digital library impact. The model draws on assumptions from the Theory of Planned Behaviour [14] and techniques from Dervin's Sense-making model and methodology[15-17] which are described in more detail elsewhere [18]. The methods are as follows:

1. Online questionnaires – investigating use of the DL within the work environment

2. Online pre and post visit (sense-making) questionnaires – investigating real-time, real-world use and how knowledge and attitudes change
3. Online tasks – how users complete tasks to find information within the library and how this changes knowledge and attitudes
4. Web log analysis – shows what users actually did within the DL
5. Interviews – to compliment these other methods by providing more in-depth qualitative data that expands on issues identified in the questionnaires and web logs.

This provides a much more in-depth picture of how a digital library may be impacting its user community and their work than previous research has allowed. The variety of methods used allows all the requirements to be met. The next section discusses how these methods and this model are implemented using knowledge and attitude as measures of impact.

The model is currently being tested on the National Resource for Infection Control (NRIC). On completion of the study in June 2008 this information provided by users at the time of visiting the library will all be linked to user activity & subsequent analysis will enable refinement of the framework and model i.e. adaptation of methods used if necessary. An insight will be provided into how the different dimensions of the library have an impact on its users.

3. Discussion

Whilst more rounded and comprehensive than previous digital library impact research, currently the model does not include methods for measuring outcomes such as prescribing rates, length of inpatient stay etc. As discussed knowledge and attitude are only indicators of intended behaviour and actual behaviour is only being evaluated by the sense-making interviews but this will only be self-reported behaviour. However, it would be possible to extend the model to include such measures, under the community dimension should there be opportunity to do so. The model has been developed within the healthcare domain and therefore the case study and scenarios used are healthcare focused. However, it should be possible to use the model in other domains as the methods described are non-subject specific but the ease of this has not yet been tested. In addition, there is no distinction between short-term and long-term impacts within the model. This is to allow the evaluator the flexibility to decide on this according to their needs and research constraints.

There are a variety of frameworks for digital library evaluation [19, 20-26], but all fall short of impact evaluation such as that presented by the model proposed. The key emphasis of most of these frameworks and their measures is on statistical measures e.g. usage statistics and satisfaction ratings. Therefore the new model presented in this paper differs from existing toolkits and frameworks in two main ways:

- It collects pre and post use data about purpose of use, knowledge and attitudes about the subject and expected impact at the point of the visit to the digital library.
- It links data from different methods to provide a picture of the impact the library has on individual users.

Its key features are:

- Universality – the aim is that this model should be able to be applied to any DL
- Objectivity – the model does not rely solely on self-reported data often subject to user perceptions but complements these by objectively collected data via Web server logs
- Versatility – using and appropriately combining multiple data collection methods to gain a rich understanding of user knowledge, attitude and behaviour change as a result of use of a DL

4. Conclusion and Future Work

This paper has discussed the need for new methodologies for digital library impact evaluation and presented a new model, Impact-ED, that is being tested in the healthcare domain. The novel approach of this model is the evaluation of knowledge and attitude changes and it is based on assumptions from the theory of planned behaviour and uses Dervin's sense-making technique. It provides a comprehensive approach to impact evaluation with mixed methods and data linkage being key. It evaluates at the time of use and activity within the library is monitored. The model is currently being used in an evaluation of the

National Resource for Infection Control digital library and will be refined accordingly when data is available. This new model provides a useful framework for evaluating user knowledge and attitude changes following use of a healthcare digital library and has the potential to be extended to include outcome measures such as prescribing rates and length of inpatient stay as well being transferable to other domains. Future research will include extension of the model to include these outcome measures as well as investigate longer-term impact. The aim is also to use the model on a non-healthcare library to test the applicability to other domains.

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