A new approach to building web-based interfaces for healthcare consumers

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Abstract
Healthcare websites, that are influential in healthcare decision-making, must be evaluated for accuracy, readability and understandability by the average population. Most existing frameworks for designing and evaluating interactive websites focus on the utility and usability of the site. Although these are significant to the design of the basic site, they are not sufficient. We have developed an iterative framework that considers these attributes longitudinally as information and structural formats change over time. The result will be websites high in 'consumer usability'.

Keywords: Internet, user-computer interface, software design, human engineering, consumer satisfaction, web design

1. Introduction

Patients have increased responsibility for their healthcare choices. Consumer retrieval of health information has never been more prevalent than it is today, with ready access to large amounts of health information on the Internet. In the past, physicians provided filtered health information to the consumer. The Internet, which is fast becoming a repository of health information, does not help the consumer to critically evaluate health information. Further, this health information is not necessarily concordant with evidence-based sources. Conflicting information is frequently found about what are considered healthy versus unhealthy lifestyle behaviours. To make informed choices between various healthcare alternatives and lifestyle behaviours, disease risk calculators are being promoted as one way to help healthcare consumers understand their risks for various

diseases. Although these risk calculators are interactive, the sites do not consistently focus on tailoring content to the general population. Over 47% of US adults have difficulty accurately integrating information with text [1]. Furthermore, even some well-educated adults have difficulty with numeracy [2]. Numeracy is numerical literacy. This has potential implications for healthcare decision-making. Websites that disseminate individualised health-related information need to be "user focused". User-focused sites must not only be designed with good utility and usability, but must also address the functional literacy of the general population. This involves ensuring that the website text and cognitive artifacts such as graphs are not only readable, but understandable at a level that enhances decision-making. We have developed a multi-prong approach for the development of healthcare websites that target the average healthcare consumer as

shown in Figure 1.

User-focused websites are modeled upon the characteristics of the user population and purpose of the site or tasks of the users. Employing cardinal axioms of good design throughout the website design lifecycle gives rise to sites that are easy to navigate, easy to read, easy to understand, easy to learn and acceptable to users. But it is not enough to design sites around only the typical user characteristics such as age, education, skill level, etc. Literacy levels and suitability of the materials for the targeted audience must be addressed as well. In addition, the content must be accurate and peer-reviewed by experts in the associated domain. Finally, the users must find the site easy to understand. It is estimated that over 23 million Americans do not understand the information given to them by their healthcare professionals [3].
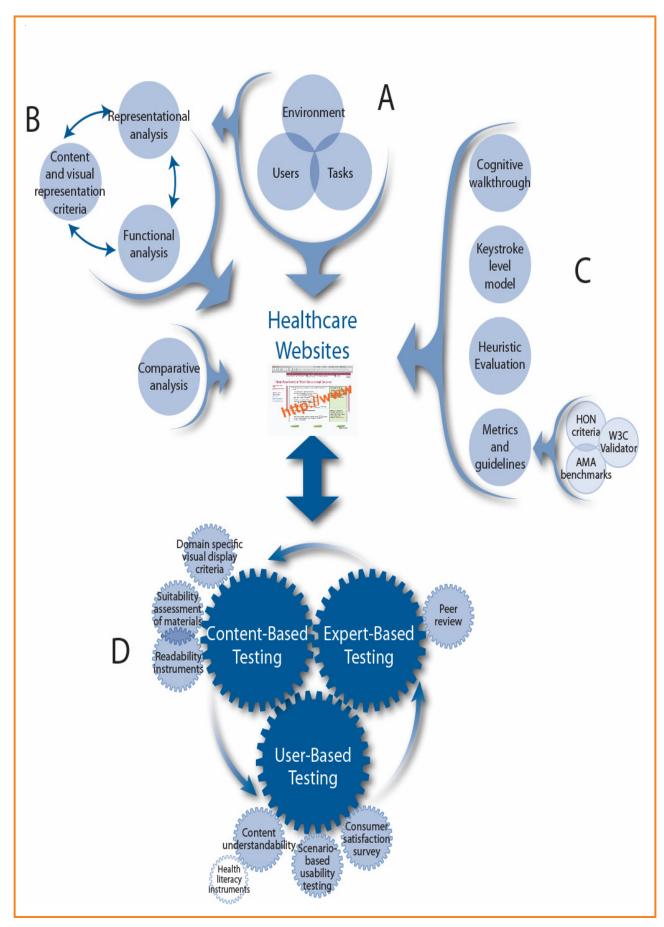
Figure 1: Website Developmental Model for the Healthcare Consumer

2. Development

2.1 User and Environmental Analysis

One of the most important issues in the design of usable web applications is to understand the people who will be using the application and match their capabilities including their reading and analytic abilities. As shown in section A of Figure 1, a user analysis is conducted to determine the characteristics of the intended users of the website, such as age, education, skill level, disabilities, cultural background, goals, computer literacy level, frequency of use, and familiarity with the domain [4]. The characteristics of the user population will dictate the layout and complexity of the interface. The major goal in the development of usable web interfaces is to design interfaces that match user capabilities. In conjunction with the user analysis, the environmental analysis specifies the conditions in which the site is used. Several aspects of the physical environment are significant to the design of the interface. The place and conditions in which the interface is used can be a deciding determinant for the type of interaction the user has with the interface [5].

Websites are accessed from around the world. Privacy of information is important, but social and cultural issues are an integral part of the analysis. The social environment of the users can impact the success or failure of a website. Social issues that need to be addressed as part of an environmental analysis are: 1) Will the user share information; and 2) Are resources readily available to assist the users [6]. Cultural issues are significant to consider and not only relate to ethnicity, but also to socioeconomic status, professional status, and regional differences [6]. Taking into account the characteristics of the users and the environment are only two points of the triad of good human-computer interaction design. We must also consider the users' tasks by using a technique called task analysis.

2.2 Task Analysis

Task analysis is the process of identifying website functions that have to be performed, the required input and output formats, website constraints, information categories and flow, and the communication needs of the users [6-9]. Essentially, it determines the goals of the users and what the users will need to do to meet these goals. A task analysis, as shown in section A of Figure 1, should ensure that only the necessary and sufficient task features that match the users' capacities and are required by the task are included in the website implementation. Ultimately, task analysis will guide the overall website design, the usability specifications, and system functionality. There are many types of task analysis and understanding the user and environment can assist in choosing the one that will provide the most information [6, 7, 9].

2.3 Representational Analysis

Representational analysis, as shown in section B of Figure 1, identifies the optimum way to display information to the user according to their task. It is an approach that breaks down a task into parts, examines the representational attributes of each part, and identifies the external representation that supports the task of the user or purpose of the website [10]. The goal in identifying the external representation that best supports the users' tasks is to reduce the cognitive load of the user and increase the ability to easily reason in complex domains. Healthcare information that is driving healthcare decision-making can be very complex and can be very difficult to understand, thus a representational analysis will ensure that the structure of the website is not a source of confusion. Additionally, a representational analysis can also be helpful in presenting complex data in an understandable representation.

2.4 Functional Analysis

A functional analysis examines the relationships of the entities within the domain, the user goals and how the users will reach these goals, the structures needed for successful goal completion, and the information flow within the website [9, 11]. Essentially, it determines the functions and overall navigation of the site. This analysis identifies top-level domain structures. Once again the content and visual criteria feed into the functional analysis and help to identify the structure of the website.

2.5 Visual-Graphical Representation

Standards are employed regarding the website content and visual representations. The selected standards will depend upon the purpose of the website, its use and its users. Strictly educational sites where information flow is uni-directional involve that the text is written at the 6th-8th grade level and provides associated pictures relating to the content. Sites that are interactive such as risk calculators where there is an exchange of information, as well as information displays, require the consideration of information display features. Features that should be considered are the effects of the display on decision processes, the form of the display, and the sequence of information within the display [12, 13].

The usefulness of graphical presentations for communication of data has become more prevalent mainly because graphical representations are easy to create. They must have a purpose, add value, and increase the clarity of the information on the website [14, 15]. Empirical research has increased to determine how people perceive statistical graphs [16, 17]. Representation of quantities such as proportions, frequencies, or percentages is frequently depicted in the length of a line, the area of a pie, or the size of a cylinder [16, 18]. Simplicity has been advocated as well. Tufte recommends using simple graphs that make the most of the "data ink ratio" [19]. Although graphic representations should look pretty, the attractiveness should not distract from the depicted data.

2.6 Comparative Analysis

Comparative analysis, as shown in section B of Figure 1, examines different aspects of other similar websites or applications on the World Wide Web. It contrasts the original application or website with the other applications or websites in terms of functionality, navigation, usability aspects of the interface screens, and user platforms. It assists with defining alternative representations, and can provide design ideas and determine what is good and what is bad about similar existing applications or websites [8].

The methods described above assist the developer(s) in the process of the creation of the healthcare website. If all of these factors are addressed, then a well-designed prototype of the healthcare website should be the result. From this prototype, an evaluation analysis is then applied.

Once the basic website is designed, then inspection methods are employed to uncover problems with user interfaces and make suggestions for fixing the problem. They are considered evaluation methods that are completed when the user interface is ready for user testing. In addition to well-published inspection methods such as keystroke level models, cognitive walkthroughs and heuristic evaluation, we suggest adding Health On the Net criteria and American Medical Association benchmarks to inspection methods for healthcare websites designed for the general consumer.

2.7 Concept Model Comparisons

Section C of Figure 1 shows the evaluation techniques needed to develop good quality websites. Comparing the users' and designers' conceptual model using the technique of the cognitive walkthrough identifies numerous problems within an interface [20]. The cognitive walkthrough can disclose many problems that a first-time user would encounter with the website functionality and ease of use. It defines how well the website supports "exploratory learning", or how well the first-time user can reach a goal

without formal training [20]. It is a technique that focuses on errors in design that would interfere with the users reaching a goal. It also explains mismatches between the users' and the designers' conception of a task. The cognitive walkthrough consists of answering a set of questions that identify the users' goals and how easy it is for the user to meet these goals. Before beginning this type of analysis, the designer must know the users, their respective tasks or goals, and the accurate action order for each task or goal [21].

2.8 Keystroke Level Models

Keystroke Level Models, on the other hand, focus on determining the execution times of individual operations within an overall task [6] such as pointing, clicking, thinking, waiting and deciding. This type of analysis provides performance estimates and ways to improve the interaction with a website by determining what tasks are consuming the most amount of time. Reduction in time is equivalent to an increase in performance.

2.9 Heuristic Evaluation

Heuristic evaluation is one of the most commonly used inspection techniques due to its low cost [22]. The test requires that a small set of experts evaluate a user interface based on their knowledge of human cognition and interface design rules of thumb [4, 8]. Heuristic evaluations are generally good at exposing the majority of usability problems within an interface. However, heuristic evaluations cannot reveal all problems, and the strength of the test lies in uncovering local problems. Using this technique along with other tests will reveal both local and global problems.

2.10 Standards of Practice

The Health on the Net Foundation Code of Conduct (HONcode) focuses on the informational aspects of healthcare websites, specifically the reliability and credibility of the information [23]. Although it is a certifica-

tion process, it does provide the guidelines considered in the certification process. Essentially, it attempts to standardise the quality of healthcare information on the web. The eight principles considered include credibility of the author(s), complementarity of the information, data confidentiality, provision for source references, balanced evidence, publication of authors, sponsorship and advertising policies.

Due to the variability of the credibility of health-related websites and the potential for commercial entities to influence the content of sites, guidelines were created for the American Medical Association to provide guidance for the creators of credible websites. Not only do these guidelines incorporate many usability principles, they also address issues regarding quality and reliability of the content, sources of the content, and funding and sponsorship of the content [24]. Adhering to these guidelines ensures that users have information regarding the credibility of the website. Lay users need websites that not only are usable, but also provide content quality and comprehensiveness.

Providing content quality also involves ensuring that the website is functional and works for different types of users with different types of devices. The World Wide Web Consortium (W3C) is an international consortium that creates Web standards and guidelines to promote "Web interoperability". Their mission is "to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure long-term growth for the Web". These standards known as W3C Recommendations are open (non-proprietary) standards [25]. Websites need to be compatible to different types of users from different types of devices including mobile devices. At a more basic level, websites need to have valid Web pages with unbroken links. We recommend, prior to launching a website, the use of the W3C Validator. The Log Validator is a tool which improves website quality by validating (X)HTML, checking hyperlinks and validating CSS stylesheets [25, 26].

Each of the guidelines and tools pro-

vided in this model helps to ensure that healthcare websites are built to be accessible to anyone, thus promoting interoperability. Yet these same websites are designed to promote exploratory learning, ease of use, and ease of understanding.

3. Evaluation Analysis

Finally, a triad of interconnecting evaluation methods, as noted in section D of Figure 1, is conducted to ensure user understandability and user satisfaction of healthcare websites. This process is inherently iterative. As one aspect is 'fixed', it may create a difficulty in another area. While these methods address different aspects, the inter-related nature of a healthcare website requires that everything be addressed until all problems or difficulties are resolved. This includes content-based testing, expert-based testing and user-based testing. The content-based testing consists of evaluating the content and graphics based on display criteria as well as readability of the site. The expert-based testing evaluates the quality and accuracy of content information by several domain experts – essentially a peer-review process. The user-based testing involves typical scenario-based testing of shell functionality and task completion, understandability of the site, and consideration of the literacy level of the targeted population, as well as tools measuring user satisfaction.

3.1 Content-Based Testing

Content-based testing must involve the use of instruments that evaluate the readability of text. There are a number of instruments that use a readability formula such as the Flesch's, Fry's or the Simple Measure of Gobbledygook (SMOG) [27-29]. However, lowering the reading level does not necessarily address understandability. On healthcare websites where consumers with any level of literacy have access, we suggest testing the site with one of the tools that uses a readability formula and evaluates cohesiveness of

text at the sentence and paragraph levels. The Readability Assessment Instrument (RAIN) uses 14 different variables to evaluate text comprehension [30]. Another tool that additionally evaluates readability, but also graphics, layout and typography, and cultural appropriateness, is the Suitability Assessment of Materials (SAM) [31]. Although the SAM was developed for use with print materials, it has also been used to assess video- and audio-taped instructions to patients. We plan to further test the instrument on web-based educational components. Lastly, there are domain-specific visual display criteria that should be considered when designing healthcare websites. For example, websites that communicate risk should follow some communication standards such as providing risk magnitude, relative risk, cumulative risk, uncertainty, and interactions [32]. Even simpler, if providing quantitative information, the elements of the graphic format must fit the represented data such as pie charts for proportions or line graphs for trends.

3.2 Expert-Based Testing

The second component in the triad is expert-based testing. Essentially this involves using experts in the content domain to evaluate the content for accuracy, reliability, and quality. While these experts may not be able to provide consumer level critical analysis of the domain knowledge, they must be sensitive to it, while providing expertise on the accuracy of the information. In addition, this component can be considered a peer review of the content on the website. A rationale for peer review is to increase the probability that inaccuracies in the content are identified and fixed. It is a way to ensure the authors that the content represents a reliable body of knowledge.

3.3 User Based Testing

The third component in this triad is user-based testing. Small-scale usability studies are an important way to validate interface design decisions and to test alternative interfaces. These

studies include talk aloud methods [20] in the controlled environment of the lab, in which the users talk about what they are doing and thinking out loud as they use the interface. This technique collects procedural information about mental processing; wherein the investigator can make deductions about problems a potential user may have with an interface. The use of audio-video recordings while the subjects are working with the interface provides a rich source of data for later coding and analysis [33]. These tests uncover hidden functional and interface design flaws. Specifically, the studies uncover differences between the users' and designers' mental models of a website.

In addition to small-scale usability studies, we test the users on their understanding of the content of the website using a qualitative approach. We begin with determining their literacy level with an instrument such as the Newest Vital Sign or Test of Functional Health Literacy in Adults (TOFHLA) [34, 35]. Either instrument reliably assesses literacy level; however, the Newest Vital Sign is a quick screening tool with only six questions. The results of this measure allow us to associate the literacy level with the results of the users' understanding of the content.

Finally we determine users' satisfaction with the website through the use of the Computer System Usability Questionnaire [36, 37]. The Computer System Usability Questionnaire is an 18-item questionnaire on a Likert scale that measures overall user satisfaction, but specifically "ease of use, ease of learning, simplicity, effectiveness, information, and user interface" [36, p66].

Taken together, these methods create a comprehensive evaluation of the healthcare website. We start with a design framework and end with an evaluation framework. We respect that there is a time commitment to a well-designed Healthcare Website. However, if the goal is a seamless experience for the consumer, developers will find that the time will have been well spent. The metric will be the number of visitors to the Healthcare Website and the comments left by the users.

4. Conclusion

A framework has been developed for healthcare internet sites that build upon well-established system design and evaluation methods. In addition to the typical suite of methods, we have added several other methods to ensure that the website content not only is functional and usable but addresses content display, readability, credibility, accuracy, and understandability to the average healthcare consumer. As connectivity continues to grow, it is imperative to construct reliable and valid tools that not only address utility and usability but also take into account health literacy levels. As more Web enabled devices enter the market, developers must scan the environment to see whether consumers are attempting to view Healthcare Websites from computers, tablets, kiosks, PDAs or cell phones. Each receiving device will create different limitations for the website developer.

The methods we used herein have important benefits toward user understanding of potentially complicated information in healthcare websites. These analyses provide the developer with tools to determine the overall functionality and usability of a website as well as test the site for user readability and understanding. An evaluation of this framework will appear later. The study to evaluate the Model is underway.

This paper demonstrates a new framework for designing healthcare websites incorporating well-documented user-centered design principles. The methods we employed in our framework show the benefits toward system usefulness, information quality, and interface quality. Incorporating user-centered design principles throughout the design lifecycle has the promise to assist in providing quality healthcare websites.

Acknowledgement

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