HCMS: Conceptual Description of a Health Content Management System

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ABSTRACT

Health is a hot topic on the Internet. Health websites are unique from other websites because they require a more acute awareness of ethical issues due to potential life threatening risks from misuse of information. We propose and give a high-level description of a Health Content Management System (HCMS) that addresses these issues and other functional needs found in most health websites. In addition, we suggest unique features that are not available in most existing health websites. Surveys of existing health websites and content management systems demonstrate the need for the proposed system. Moreover, the novelty of the proposed HCMS is appraised and asserted in comparison with similar health framework concepts. Our contributions include survey results of more than 50 health websites, a taxonomy of health websites' characteristics, and a blueprint for typical and novel features for health websites.

Categories and Subject Descriptors

D.2 [**Software Engineering**]: Requirements/Specifications; D.2.10 [**Software Engineering**]: Design—*representation*

General Terms

Design

Keywords

health website, content management system, ethics

1. INTRODUCTION

Among the myriad of websites on the world wide web, there is a considerable number of websites that provide information on health-related topics. These health websites are significant in the light that health is a popularly searched topic on the Internet. The Pew Internet and American Life project surveys have shown a steady growth in popularity of the Internet as a resource for getting health information. In 2005, 8 in 10 Internet users had searched for health topics[4], while the latest results show that 4 in 5 Internet users have sought healthcare information online[5]. Health websites are distinct from other websites because they contain information that may potentially be harmful.

This leads to challenges in how health websites should be created and managed. A typical website requires knowledge in HTML and other web technologies. In contrast, health websites also require an awareness of ethical issues, such as privacy, security, trust, etc. Actually, typical websites may not have the same level of stringency with ethical issues. For instance, a user visits a computer gaming website which has some advice about a particular game's strategy. Contrast this with a patient taking some advice about a drug from a health website. The effects of the accuracy of advice given on these two websites are distinct, from non-critical to critical. Also, suppose a patient shares their medical conditions on a health social network with a select group of users. A breach in security or privacy is more severe in this situation, compared to a typical social network with someone sharing personal stories about city tours, for instance.

The authors have previously emphasized this needs to be incorporated within the software development life-cycle[18]. In line with this perspective, we propose a Health Content Management System (HCMS) with two-fold capabilities: 1) meeting the functional requirements typical of health websites; and 2) covering ethical aspects of health websites, such as privacy, security, and trust. In this study, high-level functional requirements of the proposed HCMS are outlined, and implementation pathways are investigated. Moreover, the novelty of the proposed HCMS is appraised and examined. In addition, future implementation, evaluation and validation in terms of a pilot study are outlined. Our contributions include survey results of more than 50 health websites, a taxonomy of health websites' characteristics, and a blueprint for typical and novel features for health websites.

2. BACKGROUND

2.1 Information

The effects of 'bad' health information seem intuitively obvious, in which a suggested cure leads to a worsening condition or unhealthy side-effects. However, bad information can also be indirectly harmful. For instance, subscribers of websites such as ApricotsFromGod.com or CancerAnswer.com may be foregoing other well-established medical treatments in lieu of unverified claims[2]. The term 'information', synonymous with 'content', needs to be clarified here in the

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e-health context. This is because there is a distinction between health websites that can be used for getting health advice and and any other perceived health-related websites, such as one for a health organization. Both these websites contain information, but can be classified as quasi-critical or non-critical respectively. The quasi-critical nature of information in e-health comes from the likelihood of patients using it for self-diagnosis, treatment, or even challenge a physician's advice, which can be dangerous[17]. Non-critical information, on the other hand, is meant to be educational or promotional without the danger of being incorrectly used as advice.

2.2 Existing Online Safety Measures

Compliance with informatics ethics principles such as privacy, security, access, accountability, etc. need to be addressed within such websites[18]. At first glance, it seems this is being done. An arbitrary survey of popular health websites showed that many health websites display accreditation logos to show their compliance with ethical standards. However, a recent study found that only 66% of the websites that displayed the HONcode logo of the the Health on the Net Foundation were actually in full compliance[8]. Despite this trend, statistics show that patients and even physicians are trusting online resources[17, 9, 22]. Consequently, there is an urgent need for handling ethical concerns effectively.

2.3 Content Management

Simpler methods of building websites involve using HTML, CSS, JavaScript, etc. Higher levels of abstraction include use of templates, scripting, databases, etc. Content Management Systems (CMS) incorporate scripting, databases, and templates to build and manage websites and content. The term Content Management Systems is generally synonymous with web content management systems. The management tasks that are being done are creation, organization, and updates. These tasks are performed on content, such as text, images, audio, video, animation, etc.[6] Thousands of CMS are available on the Internet, supporting different platforms, technologies, and licensing[13]. CMS provide an unobtrusive mechanism for creating websites. The basic and common functionalities required of most websites are present by default. CMS serve as blueprints for websites. In addition, most CMS can be expanded with plugins to include additional functions such as polls, galleries, surveys, forums, blogs, wikis, journals, to mention a few. A majority of CMS come with these additional features built-in. Essentially, CMS handle the presentation front-end of websites from a back-end interface that hides some of the complexities of web technologies.

In addition to CMS, there are also Content Management Frameworks (CMF), a term sometimes used interchangeably with web application frameworks. CMF are more streamlined and bare-bones versions of CMS that facilitate the development of websites that require more flexibility in terms of functionality. In essence, CMF are more elementary, customizable, and configurable than CMS[23, 19]. While this is generally the case, many CMF actually double-up as CMS, and are full-featured. A simple illustration of these relationships for CMF versus CMS in general can be given using set notation. Let $f \rightarrow x$ = Functional attributes in x. Then, $f \rightarrow CMF \subseteq f \rightarrow CMS$.

2.4 Existing Health Frameworks

In the e-health domain, there have been attempts at building dedicated frameworks for healthcare information systems. For instance, Microsoft developed a architecture and design blueprint in 2006 that describes a Connected Health Framework (CHF), which was updated in 2009[12]. Also, UK-based companies Genetics Ltd. and EIBS Ltd. have targeted their CMS, Contensis and EasySite respectively to National Health Services (NHS) and healthcare organizations in the UK since early 2000[11, 10]. Furthermore, a US-based company, Greystone.Net has been providing e-solutions and consultations for healthcare organizations since 1996. Their services include building websites for these organizations[3, 7].

2.5 Caveat Lector

Even though these existing health frameworks are available, certain factors need to be taken into consideration. Microsoft's CHF is not a programming or development environment, but a specification. In addition, the CHF is focused on patient medical records, but does not address healthcare in terms of quasi-critical information on health topics. This is markedly different from the uses of patient records. Furthermore, the CHF takes a more business-oriented perspective on healthcare, which is only a subset of the interactions that take place in e-health.

The existing CMS focused towards health, such as Contensis and EasySite are focusing solely on organizational content of the NHS and healthcare organizations. There is no health advice being shared on these websites. Consequently, these are not websites that patients would use to get health advice or information on a health topic. Furthermore, Greystone.Net only provide advice in selection of a CMS, and do not state any in-house developed CMS/CMF focused on quasi-critical health websites.

3. FUNCTIONAL DESCRIPTION OF PROPOSED HCMS

The features expected of an HCMS cannot be arbitrary. The stakeholders need to be identified, and their interactions with each other identified to understand requirements. It is equally important to examine existing health websites to get a better understanding of expected features. Accordingly, a survey of over 50 health websites was conducted. The sampled websites were selected randomly, but with attention to enough variance in terms of popularity and search rankings.

3.1 Stakeholders

Stakeholders identified were in the context of health advice. From the survey of the health websites, there were two main users identified in this scenario: subjects and experts. 'Subjects' refers to patients or anyone seeking health information online. On the other hand, 'experts' implies physicians, users with experience in healthcare, and domain experts in health. In terms of communication, while it is normally thought that patients receive advice from physicians, it is also common for patients to take advice from others who have gone through similar situations. Three possible scenarios of how two-way communication happens between these stakeholders were identified: 1) Subject-to-Subject (S2S), 2) Subject-to-Expert (S2E), 3) Expert-to-Expert (E2E). A

fourth mode of one-way communication was also identified: Broadcast-to-any (B2X), in which the subject or expert releases information for general consumption.

3.2 Profile of Typical Health Websites

Among the 50 websites surveyed, the majority of health websites included user blogs, discussion forums or community groups, health articles, and outbound links to other websites. In addition, various websites provided health tools such as medical terms dictionaries, symptom checker, doctor search, and health trackers with personal diaries and journals.

Overall, there 3 categories of websites were identified: 1) General Topic (GT), 2) Specialized Topic (ST), 3) Specialized Demographics (SD). Health websites can be for a wide range of general health topics, diseases, or drugs. Some are more specialized for particular diseases or topics, such as websites for Cancer, HIV patients. For instance, PatientsLikeMe.com is for patients diagnosed with life-changing diseases such as epilepsy, Parkinson's, fibromyalgia, among others. Websites can also be targeting certain demographic groups such as men, women, seniors, or kids.

In terms of content, 3 methods of how content is generated were distinguished: 1) Owner Engineered Content (OEC) generated by the website administrators/staff, 2) User-Generated Content (UGC) generated by registered users, and 3) External Aggregated Content (EAC) from other websites.

Figure 1 shows the frequency of occurrence of the communication types, categorizations, and content types. Based on the survey statistics, 51% of the health websites surveyed address general topics. These topics are generated for the most part via OEC, which accounts for 46% of the websites surveyed. In addition, 56% of content was for B2X communication.

3.3 Outlier and Novel Features

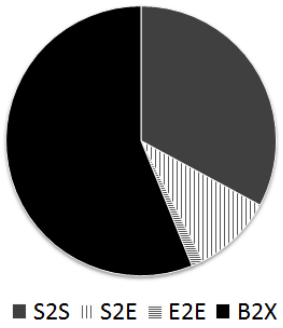
Features listed so far rely on finding commonalities across the health websites surveyed. However, two additional categories of features are available for HCMS: 1) outlier features, and 2) novel features. Outlier features are those functionalities within websites that are not common for a significant majority of websites. Novel features include any innovative functionality that is not yet provided in existing health websites.

Extensible adaptability

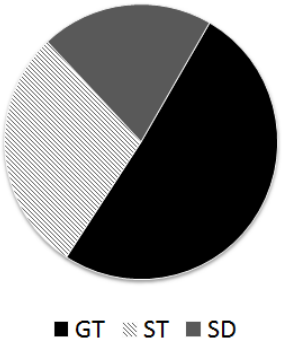
The HCMS will be based on an extensible component-based architecture that allows creation of new functionalities via new components. Also, the HCMS will be extensible to different platform technologies such as desktop computers, mobile devices, and cloud infrastructures to support the ubiquitous computing philosophy. This is a novel feature and will allow health advice to be accessed in various ways.

Privacy-Preserving Data Mining (PPDM)

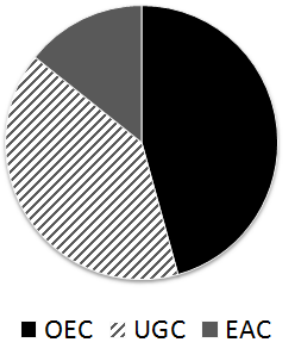
A novel feature is to incorporate multi-faceted data mining functionality within the HCMS. Various data mining tools will be built into the HCMS via its EA feature. Within data mining tasks, the need for confidentiality of data is a big issue, and privacy preservation is a critical task[1, 15]. Consequently, privacy preservation components will be added to ensure sensitive data is kept confidential.



(a) Communications



(b) Categorizations



(c) Content

Figure 1: Relative frequency of occurrence of common properties

There are different aspects of data mining in relation to the world wide web, such as web content mining, web usage mining, and social data mining. Web content mining deals with content search and retrieval while web usage mining involves analyzing user access[24]. Social data mining and social network analysis (SNA) deals with patterns of interactions between people[16]. The HCMS PPDM feature will cover these different aspects of web mining, and serve two sets of users: internal and external.

Internal users, or the users of the website will be able to get intelligent statistics and analysis based on the content and interactions. Very few existing health websites match

content with related drugs and other similar content. A recommender component in CHMS will provide users automatically categorized predictions of related topics based on what they type. Also, text summarizations of discussion treads, articles, and other long-length content will be available via machine learning techniques.

External users, or users not involved in content generation, such as researchers will be able to retrieve anonymized data from the HCMS databases for use in their data mining tasks. Web services will be built in the HCMS that will facilitate data retrieval protocols over secure connections. In addition, anonymization components will be built into the HCMS to ensure that data privacy is preserved.

It is noted that internal users will require real-time PPDM, and specific algorithms for real-time data mining will be required to provide dependable results[21].

Community knowledge

The HCMS will be able to leverage existing content from other sources, categorized into 2 groups: health content and health literature. For health content, external feeds from other health websites will be used to show related information and links. In the absence of feeds, web content extraction components will be available to directly query web pages and retrieve content in some structured manner. With health literature, information about health articles related to user discussion topics will be shown using Medical Subject Headings (MeSH) lookup[14].

Trust metrics

Although there are dedicated websites for ratings of doctors and practitioners, such as RateMDs.com, RateMyMD.ca, DoctorScoreCard.com, DoctorRate.com, and HealthGrades.com, nearly all health websites lacked incorporation of some trust metrics that give the user an indication of how trustworthy the content is. A novel feature in the HCMS will be indicators for trust for content based on a community-based ranking system combined with other analytical results.

Assisted advising

A novel feature in HCMF will be components to allow securely importing and maintaining Personal Health Records (PHRs) for patients. Patients will be able to opt to privately share these records with experts in S2E interactions. In turn, experts will be better informed through PHRs before giving advice. There are various websites dedicated to PHRs, such as Google Health, Microsoft HealthVault, and HelloHealth.com, but this is a unique feature to incorporate PHRs with health advice sharing scenarios.

Federated communication

The survey results of existing websites showed that the B2X communication mode is most popular, while E2E communication is the least common. The HCMS will facilitate all communications between the stakeholders. Physician experts will be able to communicate with each other in a private and restricted environment. Expert wikis will also be available for shared knowledge that the experts may wish to share with everyone at some point. Patient subjects will be able to communicate with each other to share knowledge and real-world experiences. Subjects will also be able to communicate with experts to get health advice.

The survey results showed that real-time chatting via instant messaging is also a rare feature. Federated communication will also allow message exchange via both Static Asynchronous Messaging (SAM) and Dynamic Synchronous Messaging (DSM). SAM will be available via mail messages and post responses. Mail messages are private messages exchanged between users on the website, while post responses include comments made to blog posts, microblog posts, and forum threads. DSM will be available via real-time instant messages with logging. A simplistic view of the federated communication model is shown in Figure 2. Directionality of communication is specified to give a relative denotation of the stakeholder that can initiate the communication.

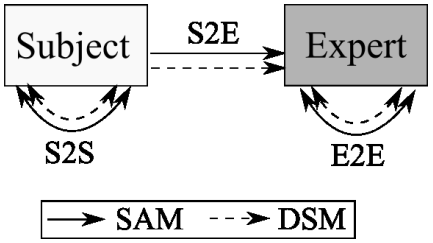


Figure 2: Health advice sharing among stakeholders

3.4 Taxonomy of Health Websites

The results above allow for a generalization of high-level properties of typical health websites. We propose a possible taxonomy shown in Figure 3 to summarize these properties. The taxonomy also includes outlier and novel features that would be available in HCMS.

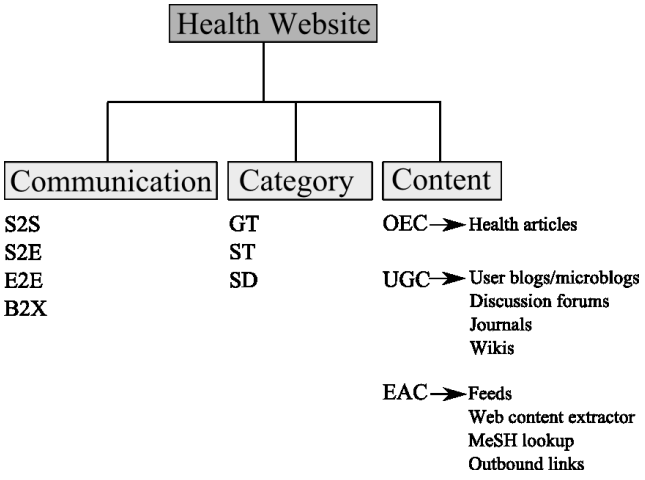


Figure 3: Taxonomy of health websites

4. IMPLEMENTATION AND EVALUATION OUTLINE

In this section, a high-level view of how the system will be implemented is provided, as well as an outline of evaluation through implementation and pilot study.

4.1 Information-Centric View of Health Websites

The core of health advice sharing websites is the information or content. We define the term 'quasi-critical information blocks' or QIB as independent entities in the content that have some related ethical concerns. QIB can be a web page, a blog post, an image, video, a forum post and so on. QIBs can also be combined together to re-form a new QIB. For instance, a group of images, text and video can all be present in one blog post, which can be a QIB. QIB can also have meta-data attached, such as the title of the blog, author, or date created. The distinguishing characteristic is the need to address ethical concerns because there is a likelihood of a QIB having potentially misleading information.

4.2 System Architecture

A high-level view of the overall concept and architecture of the HCMS is briefly introduced. Figure 4 shows a relationship between different hardware abstraction levels and software layers. This depiction is meant to compartmentalize and summarize where functional requirements will be implemented within the hardware-software context.

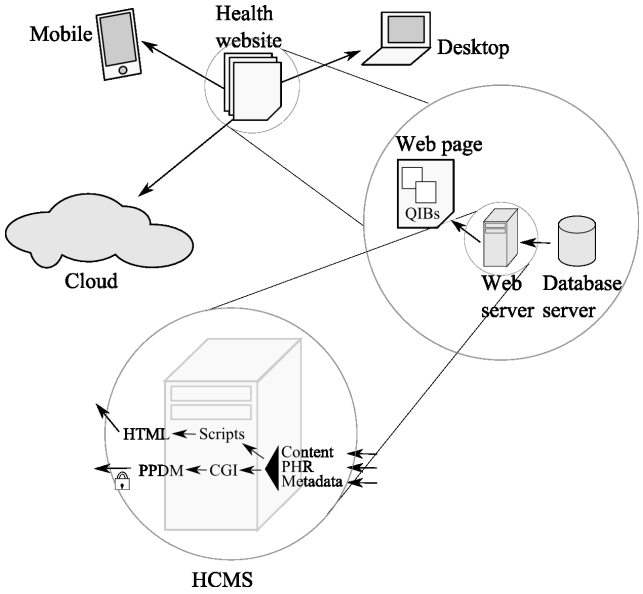


Figure 4: HCMS architecture

4.3 System Implementation

An investigation of existing CMFs was carried out using an online database of CMSs, CMSMatrix.org (CMSM). This was done to verify if there are CMFs that can be customized to provide the functions of an HCMS. The CMSM database contains various feature sets for describing each CMS.

The survey of CMFs using the CMSM database involved 3 steps. Firstly, features from the database that were relevant to the HCMS were selected. Next, CMFs were randomly selected based on their availability in the CMSM database. However, only CMFs that double-up as CMSs were used because the feature set of pure CMFs is overly limited. For instance, pure CMFs do not have blog or forum components, and these need to be re-written from scratch, which is not necessary in this case. Finally, a Match Percentage (MP) was computed for random selections of CMFs. MP is calculated as follows.

$$MP = \frac{\sum 1 \mid f \rightarrow CMSM_i = K_i}{n(K)} \times 100\% \qquad (1)$$

Since $f \rightarrow x$ gives the features of x, the results of $K = f \rightarrow CMSM \bigcap f \rightarrow HCMS$ are shown in Figure 5.

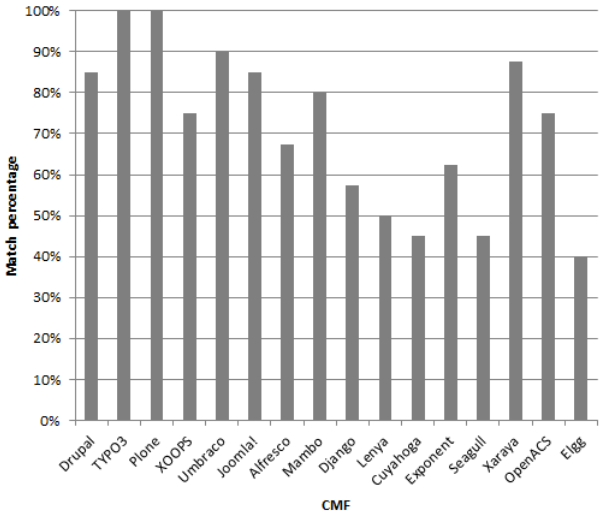


Figure 5: Match percentage of popular CMF features with HCMS feature set

The results from Figure 5 seem very promising at first glance, as TYPO3 and Plone get 100% matches. However, the issue is that a 100% match does not necessarily mean that all the features of HCMS are readily available in TYPO3 or Plone. This is because of the way the result of $K = f \rightarrow CMSM \bigcap f \rightarrow HCMS$ is gotten. It is known that $n(K) \leq min(n(f \rightarrow CMSM), n(f \rightarrow HCMS))$. However, we note that $n(K) < n(HCMS)$. That is, the features within CMFs are actually less than the feature set of HCMS.

For example, features supporting federated communication are not available in TYPO3 and Plone. Setting up E2E communication require private forums and restricted access, while S2S and S2E communications need their own separate space. This type of functionality will require installing multiple instances of TYPO3 or Plone, which will not be ideal for data mining and may lead to data redundancies. In addition, stringent privacy requirements for PHR data are not readily available. A more general illustration of the relationships between feature sets of CMFs, CMSs, and HCMS is given in Figure 6.

It should be noted that the areas in Figure 6 are generalizations and not to scale. First, it is observed that $f \rightarrow HCMS \bigcap f \rightarrow CMF < f \rightarrow CMF$. This is significant because it shows that the HCMS does not require all the features of CMF. Furthermore, only a small subset of features of CMS are needed. It is also noted that HCMS has its own unique features, viz $(f \rightarrow HCMS) - (f \rightarrow CMS)$. Moreover, both CMFs and CMSs have features that are redundant to the HCMS.

Ultimately, CMFs are useful for managing routine tasks like rendering, content arrangement, and generic privacy and

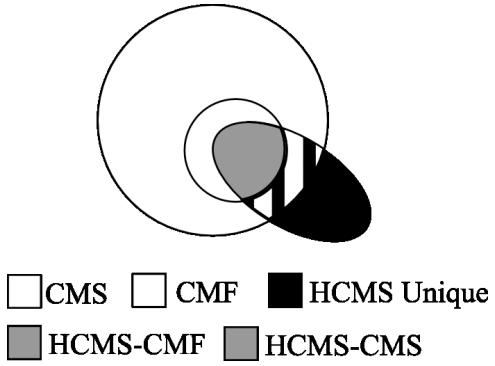


Figure 6: Feature set comparison of CMF, CMS, and HCMS

security concerns. However, CMFs need to be considerably extended to incorporate QIB requirements. Although HCMS has basic features similar to some CMFs, but the unique and outlier features are more than the CMFs provide. Consequently, we cannot translate the best selected CMFs directly into HCMS. The CMFs survey is a good starting point, but individual scrutiny of each CMF is needed.

4.4 Evaluation Plan

The health websites taxonomy in Figure 3 will be used for future evaluation of HCMS once implementation is completed. Evaluation will involve two-steps: 1) using the HCMS to generate any particular type of website based on the taxonomy; and 2) monitoring the website generated with HCMS. For instance, would the HCMS be able to build a health social network (HSN) that has S2S and S2E features? Or could it generate a simpler health website with health articles? The second step in evaluation would be to actually monitor the websites created with HCMS. A pilot study will determine how users interact with HCMS websites, and will involve getting feedback from a sample of users, patients, and experts on the HCMS websites.

4.5 Challenges

A challenge in evaluation is getting enough user involvement. There are many mature health websites already with a lot of content. In contrast, a new website created with HCMS would have little or no content initially. This is a 'chicken-and-egg' problem. Experts and users are needed to generate content, but they may not be forthcoming. The community knowledge feature is expected to help, but the challenge in getting EAC is the choice of external websites. Questions of intellectual rights arise, as well as which website's content to trust. Whereas lack of content is an issue, in the presence of legacy content, there are new issues of how to import that content into the HCMS-generated website. These challenges need to be addressed in future work.

5. CONCLUSION AND FUTURE WORK

Health is a hot topic on the Internet, and many websites are available for users to search for health advice. However, these websites can lead to harm if ethical issues are not taken into consideration. Existing CMSs and CMFs are not necessarily the best for making health websites with incorporated ethics. We propose an HCMS that is aware of ethical aspects. In addition, we also suggest unique data mining and recommender features that are not available in current health websites to the best of our knowledge. It should be noted that the work presented here is a work in progress. These initial conceptual specifications of the system are meant to facilitate the next steps of implementation and evaluation. The survey results of existing health websites, CMSs, and CMFs are valuable in quantifying the need to continue with the proposed system. The next phase of this research will involve implementation and a two-stage evaluation including a pilot study. Other future work will involve a precise definition of how ethics risks will be mitigated through QIBs.

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