
Evaluating overall usage of a digital health sciences library*

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Background: Digital health sciences library (DHSL) evaluation involves studying the usage of the DHSL by individuals as well as populations. The purpose of this study was to evaluate trends in overall usage of a DHSL as part of a process of continuous quality improvement in order to learn how to enhance a DHSL in order to meet its users' needs better. **Methods:** Web server log file analysis was performed on a prototype DHSL, the Virtual Hospital, using two log file analysis programs on data from the month of February over four consecutive years, 1995 to 1998. **Result:** Overall DHSL usage increased between 1995 and 1997 and leveled off in 1998. Fifteen percent of usage came from countries outside the United States. A broad spectrum of medical information for health care providers and patients was accessed and centered around specialty medical information. **Conclusions:** To be of optimal assistance to users, DHSLs should (1) contain a broad base of information on common and uncommon medical problems, (2) accommodate the needs of the significant percentage of users that are international through content translation and mirroring, and (3) ensure they are indexed and catalogued in the major Web search engines and Web general and medical indices so they can be easily found by users.

INTRODUCTION

Learning is now being recognized as a life long process of apprenticeship [1-4]. Health care providers are

in constant need of convenient access to high quality information to help them take better care of patients. Similarly, patients are in need of information to help them live healthier lives and take better care of themselves when ill. Thus health care providers and patients are apprentice learners whose continuum of learning requires a continuum of information support. Traditionally, access to information for health care providers and patients has been difficult, and the biggest barrier has been a lack of convenient access to information in print form [5]. With the rise of the Internet

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and its digital library technology, the Web [6], prototype digital health sciences libraries (DHSLs) that can provide global tele-education may now be constructed. The digital library may serve as an "apprentice's assistant" by lowering the barriers to accessing information by turning the tables on information retrieval; instead of the user having to go to the print library for information, the digital library now comes to the user via the Internet.

What form these DHSLs should take and what content they should contain are areas of active debate [7, 8] in this nascent field in which the first DHSL on the Web, the National Library of Medicine's HyperDoc, was started in August 1993 and the second, The University of Iowa's Virtual Hospital, moved to the Web in December 1993 [9]. Evaluation of current prototype DHSLs can play an essential role in influencing this ongoing debate. The area of DHSL evaluation is a rapidly evolving field. Currently, the majority of evaluation efforts involve the use of two complimentary electronic techniques. The first technique evaluates an individual's usage of a DHSL by using online survey forms that are filled out by individual DHSL users. The second technique evaluates overall usage of the DHSL by all users by analyzing the DHSL's Web server log file. The purpose of this study was to evaluate trends in overall usage of a DHSL as part of a process of continuous quality improvement in order to learn how to enhance a DHSL in order to better meet its users' needs.

MATERIALS AND METHODS

The Virtual Hospital®‡ is a prototype DHSL that has been in operation since November 1992. It was first implemented using Gopher technology developed at the University of Minnesota and was converted to the Web in November 1993.

The Virtual Hospital content consists of hundreds of medical booklets and books, covering hundreds of topics, divided between content created primarily for use by health care providers and content created primarily for use by patients. The health care provider content ranges from common medical topics such as low back pain to uncommon medical problems like sarcoidosis and includes a complete general medicine textbook, *The University of Iowa Family Practice Handbook* [10]. Likewise, the patient content ranges from booklets on common medical issues such as childhood immunization to specialized books on rare psychiatric disorders such as Tourette Syndrome. The booklets and books range from one to several hundred pages in length. The content is created by staff clinicians in The University of Iowa health sciences center, profes-

sional health care societies, nonprofit health care organizations, state and government health care agencies, and professional publishers. Copyright permission is obtained from the content authors in all cases. Content created by staff clinicians in The University of Iowa health sciences center is usually peer reviewed by departmental peer review boards. All content is in English. The Virtual Hospital is updated on a daily basis with new material and revisions to existing material.

In addition to being arbitrarily divided into information for patients or information for health care providers, content is further indexed by organ system, the medical discipline that created it, and the type of information including textbook, clinical guideline, or reference. To speed navigation, the DHSL's user interface is built around textual rather than graphical buttons, which speeds the loading of information and makes the DHSL easier to use.

The content, in the form of printed booklets and books, is digitized and converted to hypertext markup language (HTML) files [11]. An HTML file may contain the entire text of a booklet, a chapter of text from a book, or digital library navigation information such as a table of contents or index. Each HTML file is clearly marked with the name, credentials, affiliation of its author, its peer review status, and its date of last modification. The computer repository for these HTML files is a Netscape Enterprise Server Web server. All HTML files in the DHSL are indexed using the Glimpse search engine developed at the University of Arizona making all text in the DHSL free-text searchable [12]. The content in the DHSL is transmitted across the Internet, using the hypertext transfer protocol (HTTP) and transmission control protocol/internet protocol (TCP/IP), and is displayed on user's workstations using Web browser software. The DHSL is completely interoperable with other Web sites and maintains links to related medical Web sites.

Overall usage of the DHSL was evaluated in the month of February in four consecutive years (1995–1998), as February 1995 was the first month for which comprehensive overall usage data was available. Virtual Hospital administrative records were reviewed to determine the content that was available on the Virtual Hospital at these times. A server log file was available for each Web server. Each time an HTML or graphics file on the Web server was accessed by a user, the information recorded into the server log file included: the name of the file accessed, the time of day and day of week of access, and the Internet address of the workstation from which the user accessed the file. The identity of the user could not be recorded. In January 1998, the DHSL's Web server log file recording software was enhanced to allow the recording of the address, or universal resource locator, of the Web site that referred the user to the DHSL. This allowed the

‡ The Virtual Hospital Web site is available at <http://www.vh.org>.

Table 1
Overall DHSL usage by year

| | February 1995 | February 1996 | February 1997 | February 1998 |
|---|-------------------|---------------|---------------|---------------|
| Hits | 202,378 | 1,475,140 | 2,784,276 | 2,664,582 |
| Qualified hits | 187,831 | 1,395,191 | 2,625,109 | 2,586,812 |
| Page hits | 66,862 | 816,207 | 1,322,545 | 1,109,989 |
| Visits | 17,515 | 134,541 | 297,497 | 284,560 |
| Number of page hits received by the search page/percentage of overall page hits | (Not implemented) | 16,899/2% | 36,132/3% | 30,534/3% |
| Percentage of overall usage from the United States* | 64% | 63% | 65% | 58% |
| Percentage of overall usage from outside the United States* | 15% | 16% | 15% | 16% |
| Percentage of overall usage whose countries of origin could not be identified* | 21% | 21% | 20% | 26% |

* Measured as overall percent of bytes of information transferred by the DHSL.

determination of what percentage of referring Web sites were Web search engines (such as Alta Vista, Excite, or HotBot), or Web indices (such as Yahoo, HealthWeb, or personal home pages). Web server log file analysis was performed on the DHSL using the log file analysis programs Analog 1.2.3. developed at the University of Cambridge Statistical Laboratory, Cambridge, United Kingdom, and Wusage from Boutell.Com, Inc., Seattle, Washington. The area of Web server log file analysis has been developing rapidly, and therefore the definition of a few terms would aid understanding of the results [13].

A hit is the most basic unit of Web traffic measurement. A hit is generated by every file request made to a Web server. A hit means the Web server has transmitted a requested file to a user. That requested file can be an HTML file, a graphics file, a video file, or an audio file. An HTML file can contain other elements such as graphic files embedded within it. When a HTML file is accessed, it is logged in the Web server log file as a sequence of hits—one for the HTML file itself and one for each embedded element within the HTML file.

A qualified hit is any requested file that successfully arrives and is displayed at the user's workstation. This eliminates the counting of files that were requested by the user but were never completely delivered due to server error or user cancellation, redirects, and requests by computer programs such as Web search engines that index information on the Internet. Qualified hits are therefore a subset of all hits.

A page hit is a requested HTML file that successfully arrives and is displayed at a user's workstation. Page hits are therefore a subset of qualified hits. When counting page hits only the originally requested HTML file, or page, is counted and any additional elements embedded within the HTML file are not counted.

A visit represents consecutive file requests made at a Web site by one user, determined by their Internet address. A user's visit continues for as long as files on the Web server are accessed. If more than thirty min-

utes has elapsed between a user's file requests, a new visit is considered to have begun for that user.

RESULTS

In February 1995, the DHSL's content consisted of 12 books for health care providers and 50 booklets for patients; free-text searching of the DHSL had not yet been implemented. By February 1996, the DHSL's content had more than doubled in size and consisted of 27 books for health care providers and 200 booklets for patients, and free-text searching of the DHSL had been implemented. Most significant among the new books for health care providers was *The University of Iowa Family Practice Handbook* [14]. The addition of this book, coupled with the large number of booklets for patients gave the DHSL a critical mass of content for the first time and made the DHSL's content comprehensive in scope. By February 1997, there had been another doubling in the DHSL's content as it then consisted of 47 books for health care providers and 500 booklets for patients. Additionally, free-text searching of the DHSL was enhanced by allowing convenient access to the DHSL search page from every page in the DHSL. By February 1998, the DHSL's content had essentially remained static with 57 books for health care providers but a decrease to 400 booklets for patients as duplicate and out-of-date patient education booklets were removed from the DHSL. In February 1998, these 57 health care provider books comprised 849 megabytes of content and included 7,621 HTML files as well as 10,451 image and video files. The 400 patient education booklets comprised 32 megabytes of content and included 748 HTML files as well as 706 image files.

Table 1 shows overall DHSL usage by year. Hits, qualified hits, page hits, and visits grew rapidly between 1995 and 1997 and then leveled off and decreased slightly in 1998. Page hits received by the DHSL's search page as a percentage of overall page hits increased from 2% to 3% from 1996 to 1997 and stayed at 3% in 1998. The percentage of overall usage

Table 2
Top five countries using the DHSL by year*

| February 1995 | February 1996 | February 1997 | February 1998 |
|-------------------|----------------|----------------|----------------|
| 1. Canada | Canada | Canada | Canada |
| 2. United Kingdom | Australia | Australia | Spain |
| 3. Australia | Sweden | United Kingdom | Australia |
| 4. Sweden | Japan | Spain | United Kingdom |
| 5. Switzerland | United Kingdom | Germany | Switzerland |

* Measured as overall percent of bytes of information transferred by the DHSL.

from within the United States varied between 58% and 65%, while the percentage of overall usage from outside the United States varied between 15% and 16%.

Table 2 shows the top five countries outside the United States using the DHSL by year. The top five countries always contained Canada, Australia, and the United Kingdom.

A total of 284,560 visitors used the Virtual Hospital in February 1998. Forty percent of those visitors were referred to the DHSL by one of the Web's search engines such as Alta Vista or Excite or HotBot. The remaining 60% of visitors were referred to the DHSL by either entering the DHSL's address, or universal resource locator, directly into their Web browser or by following a link from another Web site including a Web index such as Yahoo or HealthWeb or another DHSL such as Oncolink or a personal home page. This data was not available for previous years.

Figure 1 shows an example of the average number of visits to the DHSL by day of week for February 1996. DHSL usage remains steady throughout the week, with only a slight drop-off on weekends, and this usage pattern is constant from 1995 to 1998.

Figure 2 shows an example of the average number of visits by time of day for February 1996. Usage is brisk between 09:00 and 23:00, peaking at 15:00, but remaining steady between 00:00 and 08:00. All times are central standard time (CST). This usage pattern is also constant from 1995 to 1998.

Table 3 shows the top ten requested health care provider booklets or book chapters by year. The topics covered span a broad spectrum of content for health care providers. Table 4 shows the top ten requested patient booklets or book chapters by year. The topics covered span a broad spectrum of content for patients.

In February 1998, the 57 health care provider books accounted for 48% of overall usage of the DHSL, with the 400 patient education booklets accounting for 8% of overall usage of the DHSL. The balance of DHSL usage was accounted for by DHSL administrative and navigational information. This data was not available for previous years.

DISCUSSION

Online survey forms and Web server log file analysis are complimentary techniques for evaluating DHSLs. Evaluations based upon online survey forms have the

Figure 1
Average number of visits by day of week

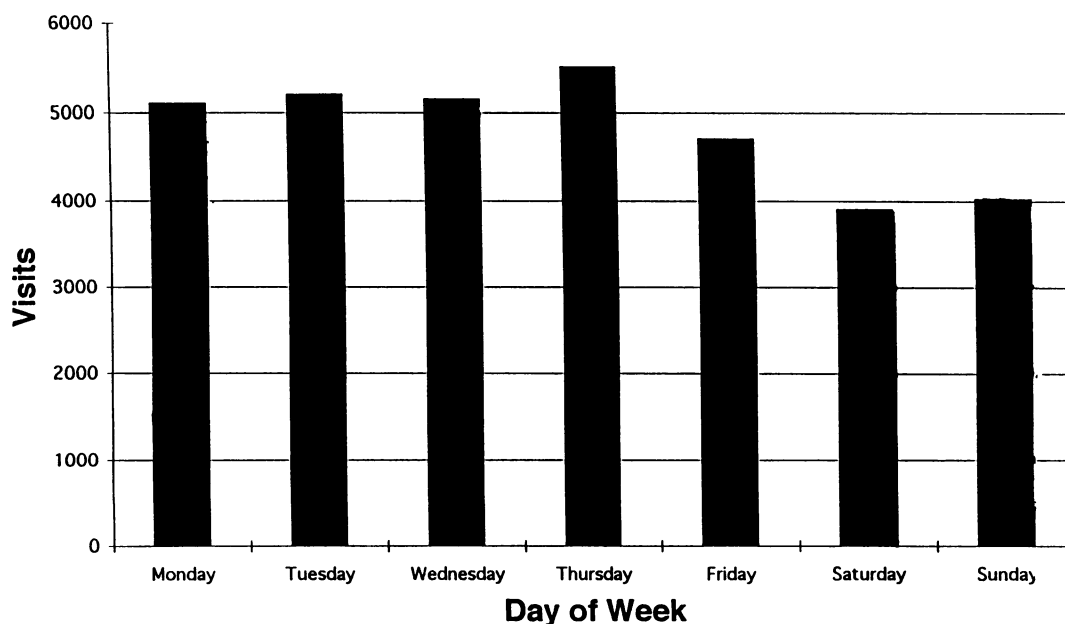
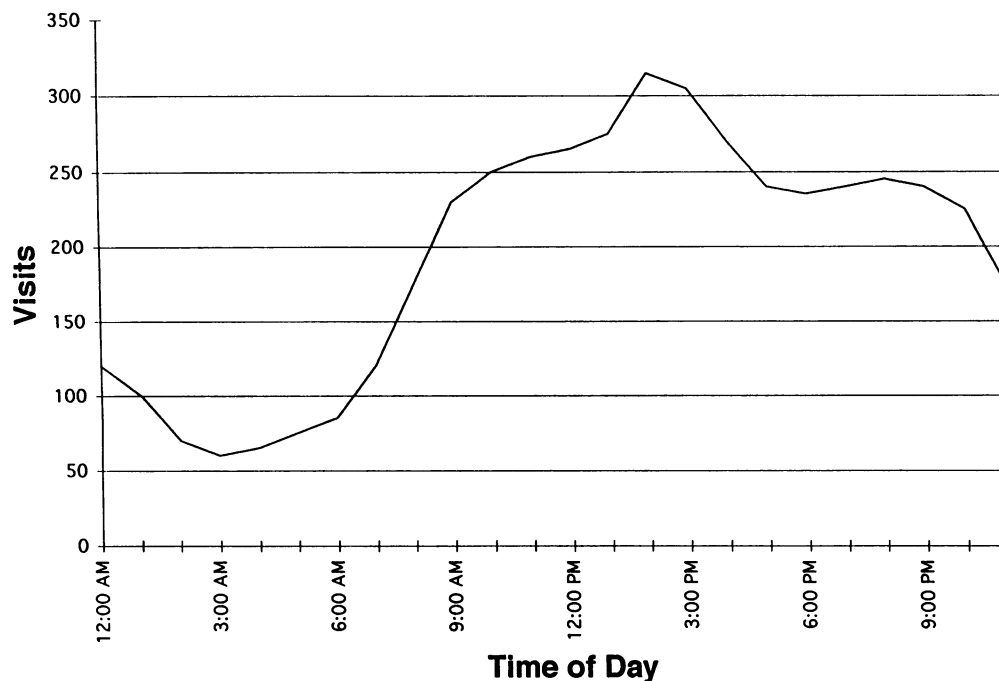


Figure 2
Average number of visits by time of day (CST)



benefit of being able to study an individual's usage of the DHSL. Unfortunately, users do not like to fill out online survey forms, and therefore evaluations based upon online surveys often result in unrepresentative samples of the users. A usage analysis of a primary care medical reference on the Internet over a one-year time period has shown it was used by 118,804 individuals, but only 118 (0.1%) have voluntarily filled out comment forms [15]. If users are forced to fill out online surveys before they can access the services of a DHSL, the online surveys function as a barrier to access and usually lead to a significantly decreased usage of the DHSL [16].

Evaluations based upon Web server log file analysis have the benefit of being able to study overall usage of the DHSL, but have several limitations. First, log file analysis reveals overall usage data, but reveals nothing about individual users. Second, the number of hits and all figures derived from this analysis underestimates the usage of the DHSL. This occurs because many universities and Internet service providers cache, or store, popular Web sites locally. Thus, when one of their users requests a page from a Web site, the request may be filled locally rather than at the actual site, and therefore the actual site does not receive credit for serving that page. Third, this analysis reveals what users find

Table 3
Top ten requested health care provider booklets or book chapters in descending order by year

| February 1995 | February 1996 | February 1997 | February 1998 |
|---|-------------------------------------|-------------------------------|-------------------------------|
| 1. Pediatric Airway Case Study #1 | Defecation | Defecation | Defecation |
| 2. Imaging of Disk Disease | Imaging of Disk Disease | Imaging of Disk Disease | Imaging of Disk Disease |
| 3. Pediatric Airway Case Study #2 | Imaging of Sarcoidosis | Hypertension in Pregnancy | Induction of Labor |
| 4. Anatomy of Pediatric Airway | Croup Syndromes | Skin Infections | Hypertension in Pregnancy |
| 5. Croup Syndromes | Pediatric Airway Case Study #1 | Croup Syndromes | Appendicitis |
| 6. Pulmonary Embolus Case Study #21 | Lobar Anatomy of the Lung | Systemic Lupus Erythematosus | Systemic Lupus Erythematosus |
| 7. Lobar Anatomy of the Lung | Muscular Anatomy of the Pelvis | Renal Failure | Skin Infections |
| 8. Pulmonary Embolus Case Study #21 | Top Ten Questions about Lung Cancer | Induction of Labor | Acute Pancreatitis |
| 9. Morbidity and Mortality Weekly Report 1/6/95 | Imaging of Emphysema | Sexually Transmitted Diseases | Early Antepartum Hemorrhage |
| 10. Pulmonary Embolus Case Study #3 | Rheumatoid Arthritis | Early Antepartum Hemorrhage | Sexually Transmitted Diseases |

Table 4
Top ten requested patient education booklets or book chapters in descending order by year

| | February 1995 | February 1996 | February 1997 | February 1998 |
|-----|---------------------------------------|---------------------------------------|--|--|
| 1. | Understanding Acute Low Back Problems | Understanding Acute Low Back Problems | Genital Herpes in Women | Insomnia |
| 2. | Causes of Low Back Pain | Sexually Transmitted Diseases | Knee Replacement | Continuous Hormone Replacement after Menopause |
| 3. | About the Back and Back Problems | Tourette Syndrome | Continuous Hormone Replacement after Menopause | Vaginal Yeast Infections |
| 4. | Things to Do about Low Back Problems | Rheumatoid Arthritis | Tourette Syndrome | Genital Herpes in Women |
| 5. | What to Do if Someone Is Poisoned | Hip Replacement | Vaginal Yeast Infections | Genital Herpes in Men |
| 6. | Exercising with Back Pain | Genital Herpes | Genital Herpes | Emotions during Pregnancy |
| 7. | Getting Relief from Back Pain | Knee Replacement | Sexually Transmitted Diseases, HIV, AIDS | Migraines |
| 8. | Surgery for Low Back Pain | Causes of Low Back Problems | Hip Replacement | Interstitial Lung Disease |
| 9. | Poisonous Plants | Insomnia | Knee Arthroscopy | Fifth Disease |
| 10. | Rosacea | Things to Do Now for Back Pain | Medical Treatment of Tourette Syndrome | Tourette Syndrome |

in the DHSL, but does not reveal what they are looking for initially. Fourth, visits represent visits and not unique users. The exact number of unique users who visit a site within a specific period of time can only be determined with some form of user identification or registration. User identification has not been implemented on this DHSL because it has been shown to be a barrier to access [17]. Finally, this analysis compared data from the same month over four years. Given the seasonal nature of some diseases, the results could possibly differ if the study is repeated in a different season of the year. Consideration was initially given to analyzing the log files for entire years, but this analysis was regarded as impractical due to the large size of the log files.

Despite these limitations, this analysis provided an initial understanding of what the DHSL was used for, where it was used from, and how it was used. Several interesting trends could be discerned. The Internet has been estimated to be doubling in amount of content and number of users each year [18]. Between 1995 and 1996, overall usage of the DHSL increased by 700%, and between 1996 and 1997 overall usage again doubled. However, overall usage of the DHSL remained relatively constant between 1997 and 1998. There were several possible explanations for this finding. First, content on the DHSL doubled between 1995–1996 and 1996–1997 but stayed relatively constant between 1997–1998 as many of the patient education booklets were revised or discarded if outdated. Second, organization of the DHSL stayed relatively constant from 1995 until mid-1997 when the DHSL was completely reorganized. Many of the links made by outside Web sites to the DHSL's content were broken and users were impeded from finding the information they were seeking. Third, the Virtual Hospital had relatively few compatriot DHSLs in its formative years to compete against, but today there are many other DHSLs that

the Virtual Hospital must compete with for users. Finally, the Virtual Hospital contains a broad base of content, which is more difficult to categorize in Internet medical indices compared to its competitors whose content is usually focused around a medical specialty, organ system, or particular disease.

The percentage of overall usage whose countries of origin could not be determined was surprisingly high (20–26%), and appears to be increasing. Every computer on the Internet must have a unique Internet protocol (IP) address that is a number (such as 129.255.136.195), and should have a unique alphanumeric name as well (such as certainsound.radiology.uiowa.edu) assigned to the IP address. Due to the current shortage of trained computer technicians needed to configure and operate the Internet infrastructure properly, unique alphanumeric names have not always been assigned to IP addresses, which has inhibited the determination of a computer's country of origin. This meant that the percentage of overall usage from the United States was probably closer to 80%, while the percentage of overall usage from outside the United States was probably closer to 20%, with these percentages staying essentially constant over time. Of the top five countries found to be using the DHSL each year, three of them were the largest English-speaking countries outside the United States (Canada, Australia, United Kingdom) and the remaining countries have taught English heavily in school and had English as an unofficial second language (Sweden, Switzerland, Japan, Germany, Spain). International data transmission speeds have usually been slow and quite costly due to high surcharges, which have effectively restricted Internet usage from foreign countries. Clearly, international usage of the Virtual Hospital would grow if its content could be translated to foreign languages and if it could be mirrored, or duplicated, in

countries around the globe allowing for quick and low cost local access.

The growing importance of Web search engines in facilitating users in finding information on the Internet is demonstrated by this study. Starting from humble beginnings in 1993 and 1994, Web search engine technology has advanced significantly and while it has limitations [19], it is still relied upon by a significant number of users to locate information on the Web. In February 1998, fifteen Web search engines referred 40% of the DHSL's visitors to it. The importance of having a DHSL thoroughly indexed by these Web search engines is paramount if a DHSL is to be found easily by its potential users. Being catalogued in Web indices (such as Yahoo or HealthWeb) is equally important as they account for the balance of the referrals. Furthermore, a DHSL must also provide its own search engine to allow its users to free-text search the content of the DHSL. The importance of this has been demonstrated in previous studies [20] and confirmed in this study when convenient access to the DHSL's search engine was provided from every page in the DHSL between 1996 and 1997, leading to a significant increase in use of the DHSL's search page.

The information accessed by users in 1995 comprised a rather narrow spectrum, which was an artifact of the limited content within the DHSL at that time. Once the DHSL reached a critical mass of content in 1996 and became even more comprehensive by 1997, users began to access a broad spectrum of content. Health care provider and patient education content accessed varied little between 1997 and 1998, and revolved not around common primary care problems (hypertension, angina, upper respiratory infections, etc.) but instead centered on specialty problems in orthopedics, obstetrics and gynecology or women's health, dermatology, general surgery, and psychiatry. This demonstrated the necessity of having a broad spectrum of primary care and specialty medical information within a DHSL in order to make it of greatest assistance to its users.

When this overall usage analysis was compared with an analysis of electronic mail sent to the same DHSL [21], there was substantial concordance and two areas of discordance. Both analyses found international usage accounted for approximately 20% of overall usage. Both analyses further found the users' information requests centered around specialty problems rather than primary care problems. In contrast, the electronic mail analysis found that 33% of all electronic mail messages concerned children and adolescents, but in 1997 and 1998 only one of the top twenty requested health care provider and patient books and booklets in the overall usage analysis related to pediatrics. Finally, although the largest population of users in the electronic mail analysis was patients and laypersons (37%), the overall usage analysis showed the

patient education booklets accounted for significantly less usage (8%) than the health care provider books (48%). Part of this might be due to having much less patient than provider content on the DHSL. Part might also be attributable to patients and laypersons reading not only the patient education booklets intended for them but the health care provider books as well. Until now patients and laypersons have never had convenient access to health care provider information. This leveling of the information gap between health care providers and patients promises eventually to transform health care [22].

CONCLUSION

In summary, the tasks that need to be performed to enhance the Virtual Hospital DHSL are clear. Broad-based content creation for health care providers and patients on common and uncommon medical problems will be continued. The needs of the significant percentage of users that are international will be addressed by implementing translation and mirroring of DHSL content. More attention will be paid to the major Web search engines and Web general and medical indices to ensure the DHSL's content is properly indexed and catalogued within them. By undertaking these tasks, the Virtual Hospital will be able to continue its growth and continue to be a useful DHSL to patients and health care providers around the world.

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REFERENCES

1. NORMAN DA, SPOHRER JC. Learner centered education. *Commun ACM* 1996 Apr;39(4):24-27.
2. SEELY BROWN J, COLLINS A, DUGUID P. Situated cognition and the culture of learning. *Educ Res* 1989;18(1):32-42.
3. HOLT J. Learning all the time. Reading, MA: Addison Wesley. 1989:148-62.
4. RESNICK LB. Learning in school and out. *Educ Res* 1987;16(8):13-20.
5. COVELL DG, UMAN GC, MANNING PR. Information needs in office practice: are they being met? *Ann Intern Med* 1985 Oct;103(4):296-99.
6. BERNERS-LEE T, CAILLIAU R, LUOTONEN A, NIELSEN JF, ET AL. The World Wide Web. *Commun ACM* 1994 Aug;37(8):76-82.
7. BRAUDE RM, FLORANCE V, FRISSE M, FULLER S. The organization of the digital library. *Acad Med* 1995 Apr;70(4):286-91.
8. LUCIER RE. Building a digital library for the health sci-

- ences: information space complementing information place. *Bull Med Libr Assoc* 1995 Jul;83(3):346-50.
9. NATIONAL CENTER FOR SUPERCOMPUTER APPLICATIONS. NCSA What's new [Web document] Champaign-Urbana: University of Illinois, 1993 [rev. 28 Dec. 1993, cited 1 Apr. 1998]. Available from Internet: (<http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/Docs/archive-whats-new.html>).
 10. GRABER MA, TOTH PP, HERTING RL, EDS. *The University of Iowa family practice handbook*. 3d ed. St. Louis: Mosby, 1997.
 11. D'ALESSANDRO MP, LACEY DL, GALVIN JR, ERKONEN WE, ET AL. The networked multimedia textbook: a technique for the global distribution of radiology multimedia information across the Internet. *AJR* 1994 Apr;163(5):1233-37.
 12. MANBER U, WU S. Glimpse: a tool to search through entire file systems. In: *Proceedings of the Usenix Winter 1994 Technical Conference*. San Francisco, California: Usenix, 1994:23-32.
 13. Internet Profiles Corporation. [Web document] Redwood City: IPRO, 1998. [rev 12 Jan 1998, cited 1 Apr 1998]. Available from Internet: (<http://www.ipro.com>).
 14. GRABER MA, ALLEN RJ, LEVY BT, EDS. *The University of Iowa family practice handbook*. 2d ed., St. Louis: Mosby, 1994.
 15. GRABER MA, D'ALESSANDRO DM, D'ALESSANDRO MP, BERGUS GR, ET AL. Usage analysis of a primary care medical resource on the Internet. *Comput Biol Med*. In Press.
 16. NIELSEN JF. Alertbox: loyalty on the Web. [Web document] Palo Alto: useit.com, 1997 [rev 1 Aug 1997, cited 1 Apr 1998]. Available from Internet: (<http://www.useit.com/alertbox/9708a.html>).
 17. IBID.
 18. BELL G, GEMMELL J. On-ramp prospects for the information superhighway dream. *Commun ACM* 1996 Jul;39(7):55-61.
 19. LAWRENCE S, GILES CL. Searching the World Wide Web. *Science* 1998 Apr 3;280(5360):98-100.
 20. NIELSEN JF. Alertbox: search and you *may* find. [Web document] Palo Alto: useit.com, 1997 [rev 15 Jul 1997, cited 1 Apr 1998]. Available from Internet: (<http://www.useit.com/alertbox/9707b.html>).
 21. D'ALESSANDRO DM, QIAN F, D'ALESSANDRO MP, OSTREM SF, ET AL. Performing continuous quality improvement for a digital health sciences library through an electronic mail analysis. *Bull Med Libr Assoc* 1998 Oct;86(4):594-601.
 22. KASSIRER, JP. The next transformation in the delivery of health care. *N Engl J Med* 1995 Jan;332(1):52-54.

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