Evaluation of a Web-Based Malaria Education Module for Hospital Pharmacists

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INTRODUCTION

Malaria is a serious tropical disease that is an increasing problem for many hospitals across Canada. Between 370 and 460 cases are reported annually in this country,[1] and these numbers are known to underestimate the true incidence by 30% to 50%.[2] Between 2001 and 2006, a mean of 17.2 cases of severe or complicated malaria were reported to the Canadian Malaria Network each year.[3] This rate may rise with increases in the number of people at risk for malaria and the number with the disease who actually present to the Canadian health care system for care. Increases in the numbers of immigrants, refugees, travellers, and military personnel returning from service overseas are some possible contributors to this trend. Locally, cases reported in the Calgary Health Region may account for 4% to 8% of the national caseload. The drug of choice for severe malaria in Canada (quinine, administered intravenously) has restricted availability and can be obtained only through 13 repository sites designated by the Canadian Malaria Network. These repositories are located in all provinces except New Brunswick and Prince Edward Island; no repositories are located in the Northwest Territories, Yukon Territory, or Nunavut.

Most cases of malaria in the Calgary Health Region are caused by the potentially deadly parasitic species *Plasmodium falciparum*; such infections can progress to organ failure within 24 to 48 h after introduction to the bloodstream. For people infected with *P. falciparum*, timely recognition and appropriate antimalarial treatment are essential to minimize associated morbidity and mortality.[4] Yet, in a review of 100 consecutive malaria cases in the greater Toronto area, 23% of the patients had delays of greater than 6 h before initiation of antimalarial therapy (after receipt of a laboratory-confirmed diagnosis), and 36% of patients infected with *P. falciparum* had no follow-up within the first 4 days of therapy.[4] Incorrect treatment regimens and errors in initial management of severe malaria were 2 "major errors" cited. Nationally, the Canadian Malaria Network reported treatment delays of more than 24 h in 17.5% of severe or complicated malaria cases over the period 2001 to 2006.[3]

These factors led pharmacy department staff of the Calgary Health Region to ask, "How prepared are pharmacists to deal with uncommon yet important malaria orders in the dispensary?" Observations in acute care dispensaries in the Calgary Health Region revealed that malaria resources (e.g., hard-copy publications, bookmarked websites) at individual workstations were limited and that few pharmacists knew that there was an infectious diseases consultant with advanced training in travel and tropical health on staff. Importantly, several drug information sources routinely used by pharmacists in the Calgary Health Region are published in the United States, where quinidine for IV administration is available and is currently used as first-line treatment for severe malaria. Use of such references could lead to discrepancies or errors in dosing under the current Canadian guidelines.

Published evaluations have shown positive results of using web-based media to educate pharmacists and pharmacy students.[5-7] This literature, along with local confusion and delays in treatment experienced within the Calgary Health Region, prompted the development of a malaria education initiative for pharmacists that was disseminated through the region's internal pharmacy website. The module was intended to support inpatient dispensary pharmacists in the management of malaria and to aid in the timely administration of antimalarial therapy. This study was undertaken to evaluate the effectiveness of the module in making pharmacists more knowledgeable about the triage process for malaria,

regional procedures concerning supplies of quinine for IV administration, and the locations of standardized malaria information. The secondary objectives were to evaluate pharmacists' comfort levels in processing malaria orders and user satisfaction with respect to the web-based education module.

METHODS

The Web-based malaria educational module was developed using information from the 2004 recommendations of Canada's Committee to Advise on Tropical Medicine and Travel,[8] the 2006 guidelines of the Infectious Diseases Society of America,[9] the 2006 guidelines of the World Health Organization,[10] other relevant literature, and expert advice. The educational content consisted of general information about malaria and its management (e.g., background, life cycle of the parasite, dosing regimens for antimalarial drugs, monitoring), updated regional monographs about IV administration of quinine (for adults and children), procedures concerning supplies of quinine in the Calgary Health Region, frequently asked questions, and a section containing links to other reliable malaria-related information.

After ethics approval for the study was obtained from the University of Calgary Conjoint Ethics Board and continuing education accreditation for the module was granted by the Alberta College of Pharmacists, the module was made available via a link on the main Pharmacy Services web page of the internal Calgary Health Region website from March 16 to May 16, 2007 (62 days). Data collection was undertaken during this time. Three reminder e-mails were sent to all of the region's pharmacists (at baseline, at 3 weeks, and at 6 weeks) to solicit participation. An e-mail address was provided within the module to which pharmacists could send specific questions or feedback. Pharmacists who completed both the pre- and the post-tests (described below) were awarded 2 h of provincial continuing education credits.

We used a prospective pre–post test study to measure the effectiveness of the educational module. Within the educational module, users first encountered an introductory page stating that the malaria educational materials and the pre- and post-tests were part of a pharmacy residency research project approved by the University of Calgary Conjoint Ethics Board. The reasons for collecting the data, what was to be done with the data, and who was involved were clearly stated, to ensure that pharmacists would be fully informed about the study. Participation in the learning assessment was voluntary, and completion of the module and the associated tests implied informed consent. A link at the bottom of the introductory page directed pharmacists first to the pre-test and then to the educational module. However, in the event of an actual case of malaria requiring urgent access to information, pharmacists did not have to complete the pre-test to access the educational materials. After reviewing the educational materials, pharmacists were directed to the post-test (which was identical with the pre-test). Web links allowed pharmacists to move back and forth between screens at any time.

The entire module and evaluative tests were pilot-tested by 2 pharmacy clinical practice leaders, 2 pharmacy managers, and 1 inpatient pharmacist. Rates of completion of the educational module were determined relative to the total number of eligible inpatient pharmacists. The primary educational end points were change in pharmacist knowledge overall, change in knowledge about the triage process of *P. falciparum* infection, and change in knowledge of procedures for procuring supplies of IV quinine. User satisfaction with the module and the comfort level of each pharmacist in processing malaria orders were assessed qualitatively.

On both the pre- and the post-tests, the user was asked to enter his or her name, number of years of hospital experience, and e-mail address, and to quantify any prior experience with cases of malaria. This section was followed by a series of 12 multiple-choice questions assessing the pharmacist's knowledge of the triage process for *P. falciparum* malaria (10 questions) and the procedures for procuring supplies of IV quinine (2 questions). The post-test also included, in addition to the same 12 knowledge questions, 6 Likert-scale questions to evaluate user satisfaction. Once completed, all test results were automatically forwarded (via e-mail) to a secure e-mail account and were then manually entered into a database (Microsoft Access 2003) for analysis.

Nonpharmacist staff (technicians and assistants) and pharmacists who did not work in inpatient dispensaries (managers, outpatient pharmacists, clinical practice leaders, and the pharmacy director) were excluded from the analysis. Of a total of 182 pharmacists in the Calgary Health Region, 122 pharmacists were working in inpatient dispensaries as of March 1, 2007, and were eligible for participation in the study. Pharmacists who did not complete both the pre- and post-tests properly and in the correct order were excluded from some analyses.

Preliminary sample size calculations were not undertaken because the educational module was not intended to achieve a prespecified change in pharmacist knowledge or a prespecified target level of pharmacist knowledge. Data were obtained from a fixed volunteer sample, and completed pre- and post-test results were analyzed according to each defined end point. Pre- and post-test questions were scored according to a standardized key, and the percentage of correct answers was determined for each pharmacist; the percentage of pharmacists with the correct answer was also determined for each question. The test results were also analyzed by subsection (triage process for malaria and procedures for procuring supplies of IV quinine). Changes in knowledge were calculated as post-test score minus pre-test score, and descriptive summary statistics were evaluated. Confidence intervals were determined for the mean test results and the mean score changes. Mean score changes were evaluated by the Student t test (with $p < 0.05$ considered significant).

RESULTS

In total, 62 (50.8%) of the 122 eligible inpatient pharmacists participated in the educational module. Of these, 2 pharmacists did not complete the post-test and 3 were excluded from the pre-test analysis because they completed the post-test first. Therefore, test results for 57 (46.7%) of the 122 eligible pharmacists were available for full analysis. On average, pharmacists had 8 years of experience working within inpatient dispensaries, and 27% (17/62) had some prior experience in dealing with orders for antimalarial medication.

For 9 of the 10 questions about triage management of malaria, the percentage of pharmacists with the correct answer increased by 13 to 54 percentage points after implementation of the module (Table 1). For the question asking pharmacists to select the most appropriate candidate for oral antimalarial therapy from among 3 scenarios, the percentage of respondents with the correct response was low both before and after implementation of the module. When asked how quinine for IV administration is supplied in the Calgary Health Region, all of the pharmacists gave the correct answer in the post-test, an improvement over 81% in the pre-test. When asked what information was essential for the release of IV quinine, 95% of pharmacists who took the post-test correctly identified the patient's full name, age, and weight, also an improvement over 49% in the pre-test.

The average of all pharmacists' pre-test scores was greater than 50%. Pharmacists' pre-test scores were unaffected by their experience with malaria (or lack

Table 1. Test Results Before and After Implementation of a Web-Based Educational Module about Antimalarial Therapy

	Phase of Study; No. (%) of Users with Correct Answer			
Question*	**Before (n = 59)**		**After (n = 60)**	
Triage process for malaria infection				
Screening to identify the most appropriate and most urgent order for antimalarial medication	39	(66)	58	(97)
Scenario most appropriate for oral antimalarial therapy	8	(14)	8	(13)
Scenario most appropriate for IV antimalarial therapy	19	(32)	32	(53)
Symptoms and laboratory results indicative that IV route is appropriate	18	(31)	51	(85)
Course of action for severe *Plasmodium falciparum* malaria	26	(44)	34	(57)
Choice of false statement regarding treatment of severe chloroquine-resistant *P. falciparum*	27	(46)	40	(67)
Choice of true statement regarding severe *P. falciparum* malaria	34	(58)	44	(73)
Monitoring of IV quinine therapy in the Calgary Health Region	40	(68)	55	(92)
Monitoring and follow-up once IV quinine has been initiated	44	(75)	53	(88)
Antibiotic or antimalarial agent that is to be used with caution in patients with glucose-6-phosphate dehydrogenase deficiency	48	(81)	59	(98)
Procedures for IV administration of quinine				
Location of supply of IV quinine in the Calgary Health Region	48	(81)	60	(100)
Information essential for the release of IV quinine	29	(49)	57	(95)

*Test questions were in multiple-choice format.

Table 2. Comfort Level of Inpatient Pharmacists in Processing Malaria Orders

Comfort Level	Phase of Study; No. (%) of Users			
	Before (n = 59)		After (n = 60)	
Very uncomfortable	12	(20)	0	
Uncomfortable	37	(63)	18	(30)
Comfortable	10	(17)	41	(68)
Very comfortable	0		1	(2)

thereof). Overall, the mean score increased from 53.6% on the pre-test to 76.4% on the post-test. The mean increase in score for inpatient pharmacists who completed the module was 22.6 percentage points (95% CI 18.3–27.0, t_{59} = 10.3, $p < 0.001$).

After completion of the module, there were also increases in pharmacists' level of comfort in processing malaria orders (Table 2). Of the 49 pharmacists who reported feeling very uncomfortable or uncomfortable on the pre-test, 31 had increases in their stated comfort level to at least comfortable after completing the module. The percentage of pharmacists who felt comfortable or very comfortable with processing malaria orders increased from 17% to 70% after completion of the module. No individual pharmacist reported feeling less comfortable processing malaria orders after completion of the module.

More than 90% of participating pharmacists agreed that the materials provided had achieved the stated learning objectives, that the Web-based format was effective, that clear and understandable explanations had been provided, and that the organization of the materials was effective (Table 3). Conversely, most pharmacists disagreed that the module took too long to complete or that the educational materials were difficult to locate. No participants gave consistently negative evaluations on the six user satisfaction criteria. In addition, many pharmacists sent positive comments and feedback by e-mail.

DISCUSSION

Nearly half of all inpatient pharmacists in the Calgary Health Region (as of March 1, 2007) completed the educational module and participated in the pre- and post-tests. Of the target population of 122 pharmacists working within inpatient dispensaries, 57 (46.7%) submitted test scores that could be evaluated. Although it is difficult to compare this small, closed-sample participation rate with that for a large, open-sample population, this participation rate was higher than those for other pharmacist education initiatives (10% and 22.5%).[11,12] Whether the participating pharmacists were representative of the total population of inpatient pharmacists is difficult to analyze. Completion of the educational module was voluntary, and those who chose to participate might have been motivated by internal factors (e.g., higher lifelong learning values, personal interest in topic) and/or by factors more directly related to professionalism (e.g., need for continuing education credits, need to demonstrate workplace competency, support for hospital pharmacy residency). Volunteers who are motivated to participate in continuing education may learn more effectively and therefore may not represent how the entire population would learn. About one-third of the participants had no more than 2 years of hospital pharmacy experience, which reflects the high number of newly hired pharmacists in the department. Many of these new employees were recent pharmacy school graduates, who might have been more willing to participate in a Web-based module with a test component. However, a high number of new employees can tax the ability of any department to provide comprehensive orientation, which underscores the practicality of an accessible, locally applicable self-study module. Barriers to participation might have included lack of time, low priority (i.e., more pressing issues at work), or fear (since responses were not recorded anonymously). Nonetheless, there were good participation rates at each urban acute care hospital within the

Table 3. User Satisfaction with Web-based Education Module

Satisfaction Component	Response; No. (%) of Users (n = 60)									
	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
Materials achieved learning objectives	0		1	(2)	1	(2)	40	(67)	18	(30)
Web-based format was effective	0		0		1	(2)	28	(47)	31	(52)
Explanations were clear and understandable	0		0		3	(5)	40	(67)	17	(28)
Organization of materials was effective	0		0		5	(8)	40	(67)	15	(25)
It took too long to complete materials	8	(13)	37	(62)	13	(22)	1	(2)	1	(2)
It was difficult to locate educational materials	32	(53)	25	(42)	0		3	(5)	0	

region, and it appeared that pharmacists from a wide variety of clinical areas participated in the module. The Web-based design of the module made pharmacist participation more practical and even enabled educational outreach to several pharmacists working in rural satellite hospitals in the Calgary Health Region.

The increases in mean test scores indicated that the module led to an increase in knowledge for the primary end points. This increase is important in practical terms, given that pharmacists do not have a lot of opportunities to learn about malaria and given that the questions were as realistic as possible from the perspective of an inpatient dispensary pharmacist. Qualitative feedback indicated that after completion of the module, users felt more comfortable in dealing with malaria orders. It is hoped that this will translate into better performance when pharmacists direct the distribution process for malaria medications and intervene, if needed. Prompt and appropriate management of malaria by all members of the health care team can reduce malaria-associated morbidity and mortality.[4] By completing the educational module, pharmacists in the Calgary Health Region can learn how to directly contribute to the pharmaceutical care of patients with this disease.

Although no specific passing score was set for the pre- and post-tests, the average of all pharmacists' pre-test scores was greater than 50%, which might indicate that baseline knowledge was higher than expected or, more likely, that the answers to the test questions could be readily deduced. There was also an indication that some pharmacists reviewed the educational materials before completing the pre-test. In retrospect, the ability to access the educational materials before taking the pre-test was a significant design flaw that might have biased the baseline results. However, because of lack of time and lack of Web expertise, it was impractical to assign user passwords or to deny pharmacists access to the education materials until they had completed the pre-test (since information in the module might be needed urgently in the event of an actual malaria case). Allowing timely access to educational materials when needed for the provision of patient care is an important issue that needs to be addressed in the design of subsequent pre–post test studies to prevent bias.

Two of the test questions were designed to determine participants' knowledge of the criteria for severe malaria, as patients who meet these criteria and those who are unable to tolerate oral therapy should be given IV therapy. Scores on these questions and feedback from participants indicated confusion about one of these questions, which presented 3 patient scenarios and asked the following question: "You are screening orders and come across some interesting notes in the documents section of the patient care information system. For which of the following scenarios would you recommend ORAL antimalarial therapy?" The number of pharmacists who answered correctly was low for both the pre-test (8/59) and the post-test (8/60). In retrospect, the information provided in the answer choices for this question was unclear and ambiguous. A larger focus or pilot group, more stringent validation of the test questions, and the use of statistical tests for internal consistency might have improved the quality and design of the this and other test questions. Nevertheless, the impact of this question on patient care is probably minimal, since inpatient dispensary pharmacists would not likely make the final decision about route of therapy.

Pre–post testing is an effective way to measure change in knowledge among medical students and residents,[13,14] and was applied here to hospital pharmacists. However, there were several limitations to this study. First, although the module led to an increase in pharmacist knowledge, this would not necessarily translate into an increase in competency. For example, online case-based learning was only partially effective in a sample of 58 Ontario family practice physicians.[15] Stewart and others[15] found that although this type of learning was associated with an increase in knowledge and quality of practice for certain disease topics (defined as documentation in patients' charts that physicians had followed clinical practice guidelines), physician behaviour, as assessed by patients, remained unchanged. Although knowledge and competency are related, measuring an increase in competency may involve case-based experiential learning or pharmacy/pharmacist audits. Second, the pre–post tests used here could not be used to measure knowledge retention, since participants' knowledge was evaluated only twice, immediately before and immediately after they had completed the educational material. However, knowledge retention is an important consideration, since malaria is encountered only infrequently in the Calgary Health Region. As with other uncommonly encountered clinical situations, online educational materials are convenient and easily accessible. However, without regular review, the long-term effects of such Web-based educational initiatives may be limited. Further Web-based evaluation of knowledge retention or dissemination of updated malaria guidelines is not currently planned but would be feasible, given the adaptability and increasing acceptance of Web-based

materials. Periodic re-testing would be advantageous for the benefit of new staff members or when treatment guidelines have changed. Third, the number of pharmacists who completed the module was small, and the sample was confined to voluntary inpatient pharmacists within the Calgary Health Region, a group that may not reflect other inpatient pharmacist populations.

Feedback to participants in continuing professional education was a key contributor to learning in several previous evaluations.[9,16] Prompt feedback stimulates independent learning and increases ratings of perceived beneficial learning experiences. Many inpatient pharmacists asked for their scores or the answers to the test questions. An answer key was posted at the end of the data collection period and pharmacists were given an e-mail address through which they could contact the authors; however, at the time of writing, no participants had contacted the authors to discuss specific results.

CONCLUSIONS

The educational module described in this report continues to be available to pharmacists in the Calgary Health Region and will be updated as needed, for example when the Committee to Advise on Tropical Medicine and Travel issues new guidelines (release pending in 2008). A major communication effort to all Canadian health care professionals will be required if important antimalarial drugs such as the artemisinin derivatives are made available in Canada, a development that is expected to occur within the next several years. Pharmacists will be notified of any updates via the Pharmacy Services webpage and/or by e-mail.

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