science, engineering and health studies

Research Article

Science, Engineering and Health Studies
https://lio1.tci-thaijo.org/index.php/sehs
ISSN (Online): 2630-0087

DI-QC: A tool for assessing the quality of drug information websites

Somphop Thammarungsri[1], *Suang Rungpragayphan*[2*]

[1] Department of Pharmacy, Nong Chang Hospital, Nong Chang, Uthai Thani 61110, Thailand
[2] Department of Biomedicine and Health Informatics, Faculty of Pharmacy, Silpakorn University, Nakhon Pathom 73000, Thailand

***Corresponding author**:
Suang Rungpragayphan
rungpragayphan_s@su.ac.th

***Received**: 23 May 2023*
***Revised**: 3 October 2023*
***Accepted**: 8 October 2023*
***Published**: 31 December 2023*

***Citation**:
Thammarungsri, S., and Rungpragayphan, S. (2023). DI-QC: A tool for assessing the quality of drug information websites. Science, Engineering and Health Studies, 17, 23050023.

ABSTRACT

Given that the quality of drug information on the World Wide Web varies greatly, it is essential to evaluate websites and their information before use. While various tools exist for evaluating health information websites, most are either not specific to drug information or are tailored to a particular group of drugs. This study aimed to develop a tool to evaluate drug information websites for both pharmacists and consumers, and to assess its validity, reliability, and applicability. We drafted a conceptual framework for drug information website evaluation, leading to the creation of a user-guidance type evaluation tool, named DI-QC, which exists in two versions: one for pharmacists and one for consumers. Each version comprises 26 items. The validity of DI-QC was confirmed with an S-CVI/Ave of 0.86 for the pharmacist version and 0.87 for the consumer version. The reliability of DI-QC was also assessed in terms of inter-rater agreement, with results showing consistent agreement across items. To demonstrate the applicability of DI-QC, forty-four drug information websites were evaluated. Using the pharmacist and consumer versions of DI-QC, 38.64% and 34.09% of the websites, respectively, were rated as 'Good'. In conclusion, the DI-QC assessment tool was developed through a reliable process and is applicable and beneficial for evaluating drug information websites for both pharmacists and consumers.

Keywords: drug information websites; health information; quality assessment tool

1. INTRODUCTION

With the advancement of computer and information technology, the worldwide use of the Internet has grown rapidly (Internet Live Stats, 2016). In addition to consulting directly with healthcare providers, patients and their families can now easily access health-related information through the Internet. Based on a survey conducted in the US, 61% of internet users search online for health information, and 45% of US adults retrieve drug information via the web (Fox and Sydney, 2009). Moreover, the information found online has a significant impact on decisions related to the health of seekers or someone in their care.

Online health information undeniably offers value. However, there are significant concerns about the risks associated with using it, given that information on these websites is not often peer-reviewed before being posted, and the Internet remains largely unregulated. Thus, critically evaluating this information before utilizing it is essential and widely recommended (Jadad and Gagliardi, 1998). While healthcare professionals should guide patients to trustworthy online sources, particularly regarding drugs and medications, they often lack the time to vet all the available online health resources. A recognized quality indicator such as Health on the Net Foundation (HON) signifies a website's adherence to the ethical guidelines of health information

provision. Unfortunately, only a small percentage of health information websites have been assessed and certified by HON. Moreover, HON certification was discontinued in 2020 (Health on the Net Foundation, 2020). A valuable strategy is to teach patients about the risks and train them to evaluate online health information independently. The most straightforward method for people to assess health information relies predominantly on their intuitive sense of the trustworthiness of data. However, the task would be simpler if there were explicit criteria for determining the credibility of health information and websites (Silberg et al., 1997). Various tools have been developed to gauge the quality of general health-related websites (Kim et al., 1999; Bernstam et al., 2005), and some were specifically created for websites offering drug information (Luk and Aslani, 2011). Although these tools can be useful, some are specific to particular drugs (Martin-Facklam et al., 2002; Ghoshal and Walji, 2006; Yap, 2010; Nasser et al., 2012) or come with limitations (Kim et al., 2011; Robert Sabaté and Diego, 2021). Additionally, not all tools have provided data on their validity and reliability. DISCERN is a widely used validated quality assessment tool to evaluate online health information documents for choice of health-related treatment (Charnock et al. 1999; Rees et al., 2002; Rao, 2012). However, when applied to drug information, it has limitations due to its original focus being on treatment options (Luk and Aslani, 2011; Robert Sabaté and Diego, 2021). Concerning tool users, pharmacists responsible for drug information services and general consumers often require information at varying levels of complexity. As a result, assessment tools should be tailored for each user type.

This study aimed to develop a quality assessment tool for websites offering drug information, designed to measure the credibility and quality of information for both pharmacists and consumers. An assessment tool for drug information websites was created, and its validity, reliability and usability were evaluated.

2. METERIALS AND METHODS

2.1 Assessment tool development

Literature concerning the quality of websites providing drug information and the existing assessment tools was reviewed in order to construct a conceptual framework of quality criteria. Components indicative of the quality of a drug information website were identified to formulate questions and their operational definitions. Based on these definitions and measurement methods, an assessment tool was drafted, with the aim of being applicable to both pharmacists (or drug information experts) and consumers (or patients). Structured on the principles of DISCERN, the tool was divided into two parts: Part I, which deals with the credibility of the websites, and Part II, which focuses on the quality of content (Charnock et al., 1999). Part I of the tool is consistent for both user groups (pharmacists or consumers), while Part II presents distinct questions tailored to each user type. All questions are presented in Tables 1 and 2.

2.2 Content validity assessment

The initial draft of the assessment tool underwent a relevancy review by three drug information experts: two lecturers from the Faculty of Pharmacy at Silpakorn University and one lecturer from the Faculty of Pharmacy at Khonkaen University. These experts were responsible for evaluating the content validity of each question. Their suggestions and comments were gathered to further refine the tool. Both Item-level Content Validity Indexes (I-CVIs) and Averaged Scale-level Content Validity Indexes (S-CVI/Aves) were computed (refer to statistical analysis). Based on the feedback from the drug information experts, adjustments were made to the questions. Instructions for utilization, descriptions of questions, guidelines on navigating the pages and rating each question, along with the rating scale for quality assessment, were further clarified. These details were then compiled into handbooks designed for both pharmacists and consumers.

2.3 Curation of drug information websites

A comprehensive search for drug information websites was conducted using three different search engines: Google, Bing, and Ask. Three distinct search terms — 'drug information', 'medical information', and 'medication information'— were employed. The top 30 results from each search term across each search engine, amounting to a total of 270 (30x3x3), were gathered. Subsequently, duplicates were removed, and the remaining search results were screened based on the following inclusion criteria. The selected websites must: 1) Provide information in English, 2) Offer drug-related information, 3) Not be limited to articles or journal abstracts, 4) Not be social media pages, 5) Not provide information about illegal drugs, 6) Remain accessible throughout the study, and 7) Be accessible at no cost. Websites meeting all of these criteria were included in the study for further analysis.

2.4 Assessment of tool reliability

From the curated list of drug information websites, 10 websites providing information on 'Amoxicillin' (also spelled 'Amoxycillin') were chosen as sample subjects for the reliability test. Amoxicillin was selected as the model drug due to its widespread use and familiarity, anticipating that most, if not all, drug information websites would have available information on Amoxicillin. For the reliability, five pharmacists and five consumers were enlisted, labeled as 'Pharmacist raters' and 'Consumer raters', respectively. Seven days before the assessment, each rater received a copy of the assessment tool handbook for preparation. Subsequently, they were instructed to evaluate the 10 chosen websites using the assessment tool over a span of three weeks and then return all completed forms and documents. Using question 1, "Does it show transparency?" as an example, raters could award 5 points if a full statement of transparency was clearly defined. They could give 2-4 points if the intention of transparency was stated but was incomplete or unclear, and 1 point if no statement of transparency was provided. After collecting the evaluations, inter-rater agreement was computed to establish the reliability of the tool. Following the reliability test, instructions and examples in the handbook were refined based on the results to create the final version of the tools. The final version of the tools was used in the evaluation of drug information websites.

2.5 Evaluation of drug information websites

To demonstrate the applicability of the assessment tool, the authors assessed the curated drug information websites using both evaluation forms designed for pharmacists and consumers. Each website was randomly

selected for examination, focusing on webpages providing content for at least 11 of the 32 predefined generic drugs across 11 pharmacological categories. These categories were based on classifications found in 'Goodman & Gilman's the Pharmacological Basis of Therapeutics, 10th edition' (Hardman et al., 2001). For websites that distinctly separated drug information content based on the type of visitor—either pharmacist or consumer/patient—each section was evaluated separately.

2.6 Statistical analysis

I-CVIs were determined by calculating the number of experts who rated either 3 or 4, divided by the total number of experts. S-CVI/Aves were then calculated by averaging the I-CVIs for all items on the scale. It is worth noting that the recommended S-CVI/Ave is 0.90 (Polit and Beck, 2006). Inter-rater agreement was measured using quadratic weighted kappa coefficients (K_w). Additionally, the following matrices were computed: Proportion of Observed Agreement (P_o), Prevalence Index (P_{index}), Bias Index (B_{index}), and Prevalence-Adjusted Bias-Adjusted Kappa (PABAK) (Viera and Garrett, 2005; Sim and Wright, 2005). The P_o demonstrates the proportion of observed agreement among raters, with high P_o positively affecting the K_w. A high P_{index} indicates that chance agreement is also high. Bias, considered through the B_{index}, influences the magnitude of the agreement shown by Kappa coefficient. Therefore, in interpreting the Kappa, the B_{index} should be considered.

Given that PABAK, P_{index}, and B_{index} can only be defined for dichotomous variables, the initial step involved converting result values to a dichotomous scale, using a 2×2 contingency table that categorized outcomes as 'Accepted' or 'Not accepted'. P_o was calculated by summing the frequencies at which the two raters agreed and then dividing by the total number of drug information websites. P_{index} was determined as the absolute difference in frequencies between 'Accepted' and 'Not accepted', divided by the total number of drug information websites. B_{index} was computed by taking the absolute difference in frequencies between instances where the two raters disagreed on 'Accepted' and 'Not accepted' cases and then dividing by the total number of drug information websites (Viera and Garrett, 2005; Sim and Wright, 2005). PABAK was calculated using the formula $PABAK = (2\times Po) - 1$ (Cunningham, 2009).

For each question, inter-rater agreement was determined by calculating individual scores for all possible pairs of assessment results among raters in the same group. These scores were then averaged to obtain means with standard deviations. The levels of K_w and PABAK were interpreted using the recommended ranges of Kappa by Landis and Koch (1977). Similarly, we applied their ranges to interpret scales for the levels of Po, P_{index}, and B_{index} (Figure 1).

Corresponding ranges of K_w and PABAK	
0.81 - 1.00	Excellent
0.61 - 0.80	Good
0.41 - 0.60	Moderate
0.21 - 0.40	Fair
0.00 - 0.20	Slight
< 0.00	Poor
Interpretation scale for P_o, P_{index} and B_{index}	
0.81 - 1.00	Very High
0.61 - 0.80	High
0.41 - 0.60	Moderate
0.21 - 0.40	Slight
0.00 - 0.20	Poor

Figure 1. Corresponding ranges and interpretation scale for inter-rater agreements applied from Landis & Koch scale (Landis and Koch, 1977).

For P_o, P_{index}, and B_{index}, although various research studies have suggested methods for their interpretation, no definitive value has been proposed to categorize them as higher or lower. Therefore, we established a cut-off point of ≥0.41, categorizing values within this range as 'Moderate' to 'Very High'. Descriptive analysis was employed during field testing, utilizing PSPP 0.8.5, a statistical analysis tool for sampled data (https://www.gnu.org/software/pspp/), and Microsoft Excel for data compilation and all statistical calculations in this study.

3. RESULTS AND DISCUSSION

3.1 Assessment tool development

Largely drawing on the work of Cline and Haynes (2001), a conceptual framework detailing the quality criteria for drug information websites, as well as sub-components related to the completeness of drug information, was established, as depicted in Figures 2 and 3, respectively. While there are three dimensions defining website quality — credibility, content quality, and design — the design dimension was excluded from this study. This is because website design trends change swiftly, and tools for

evaluating web design already exist (Darmoni et al., 1999; Minervation, 2008; Joseph, 2015). Elements relating to credibility and content quality were extracted to facilitate the development of the assessment tool, as illustrated in Figure 2. The resulting assessment tool, named DI-QC (an acronym for Drug Information - Quality and Credibility), was customized separately for pharmacists and consumers. Each version of the assessment tool was divided into Part I, focusing on website credibility, and Part II, concentrating on content quality. Part I encompassed 12 items (refer to Table 1), while Part II had 14 items (see Table 2). Both user types shared Part I as well as 3 of the 14 items (Q13–15) in Part II. Items were organized based on the depth of navigation a user would need to sift through the website in search of relevant information, with levels ranging from easy to challenging (Bernstam et al., 2005). For evaluation, each item utilized a 5-point rating scale: 1 being 'No, it does not comply with the criteria at all' and 5 representing 'Yes, it fully complies with the criteria'.

As the tool consisted of 26 items, the total score could range from 26 to 130 points. The criteria for rating the overall quality of drug information websites based on their total score were established as follows: less than 54 points is categorized as 'Very Poor', 55–77 points as 'Poor', 78–97 points as 'Fair', 98 -115 points as 'Good', and more than 115 points as 'Excellent'.

3.2 Content validity of DI-QC

One important property of a high-quality evaluation tool used for assessing health-related information websites is to ensure that the criteria, questions, and user guidance are precise and clear, aiding users in discerning variations in website quality. Therefore, a content validity test was conducted to demonstrate the relevance between the questions and the operational definitions of the tools. The S-CVI/Aves of items in the DI-QC for pharmacists and the DI-QC for consumers were 0.86 and 0.87, respectively, both closely aligning to the recommended value of 0.9 (Polit and Beck, 2006). Based on expert suggestions, adjustments were made to the initial draft of DI-QC was adjusted. Importantly, no items were removed during this refinement process.

3.3 Drug information website curation

A World Wide Web search was conducted using three search terms: 'drug information', 'medical information', and 'medication information' across three different search engines: Google, Bing, and Ask. In general, internet users explore three or fewer search results per page (given the default display of 10 results per page), and if they do not find the information they are looking for, they change the search terms. Therefore, we decided to collect the top 30 results from each search, resulting in a total of 270 URLs (30 URLs x 3 search terms x 3 search engines). Out of these, 44 websites met all the inclusion criteria, as shown in Figure 4. Their characteristics are summarized in Table 3, and the complete list of the 44 websites is provided in Supplement 1.

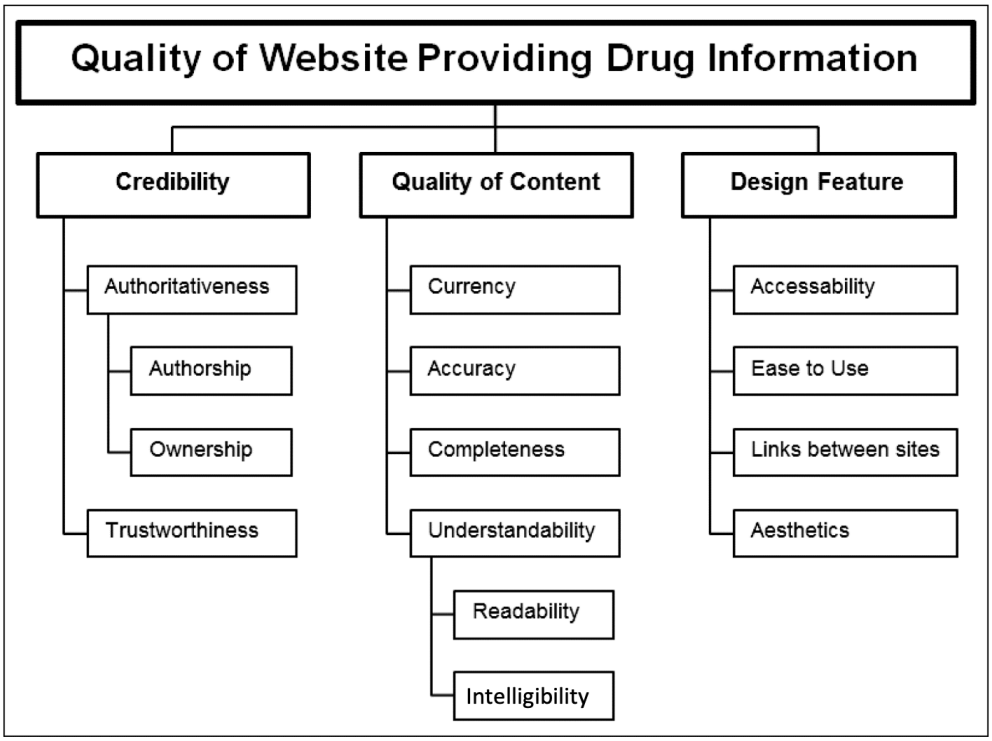

Figure 2. Conceptual framework for quality criteria of drug information websites

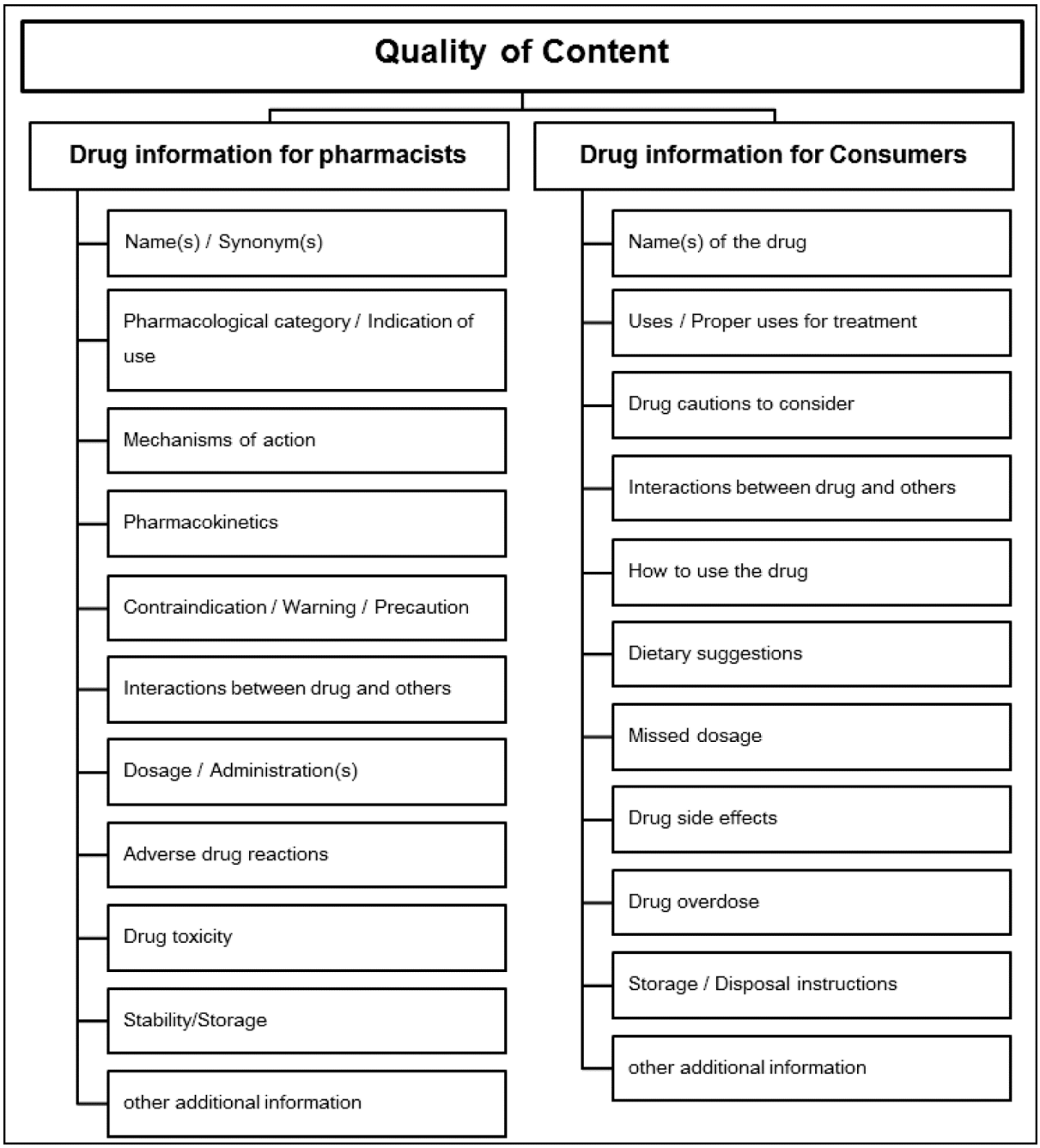

Figure 3. Sub-components for drug information completeness

Table 1. List of items in Part 1 of DI-QC (Credibility of the websites)

No.	Questions
1	Does it show transparency?
2	Does it disclose its sponsorship?
3	Does it have good confidentiality?
4	Does it provide any general disclaimer?
5	Does it have an advertising policy?
6	Is a feedback mechanism available for users?
7	Does it show who the owner is?
8	Does it show the owner's further contact information?
9	Does it have an editorial policy?
10	Does it identify who wrote the contents?
11	Does it clearly indicate the sources of information?
12	Are the sources of information available to be verified?

Table 2. List of items in Part 2 of DI-QC (Quality of content written on the drug information websites)

No.	Questions	
	Pharmacist	**Consumer**
13	Does it show when the content was created or updated?	Does it show when the content was created or updated?
14	Does it offer balanced content?	Does it offer balanced content?
15	Is its content well organized?	Is its content well organized?
16	Does it explain the names of the drugs?	Does it let you know the names of the drug?
17	Does it describe the use of the drug for treatment?	Does it tell you why this drug is prescribed?
18	Does it describe the action of the drug for treatment?	Does it tell you what you need to follow before using the drug?
19	Does it describe the pharmacokinetics of the drug?	Does it show you what other drugs will affect your drug?
20	Does it describe what the contraindications, precautions and warnings of the drug are?	Does it explain how to use the drug?
21	Does it describe the interactions between the drug and others?	Does it explain what special dietary instructions you should follow?
22	Does it describe dosage and administration of the drug?	Does it tell you what to do if you forget to take a dose?
23	Does it describe any adverse drug reactions?	Does it tell you what side effects the drug can cause?
24	Does it describe the toxicity of the drug?	Does it tell you what to do if you take an overdose?
25	Does it describe the storage and stability of the drug?	Does it explain the storage and disposal instructions for the drug?
26	What about other descriptions?	Does it explain what other information you should know?

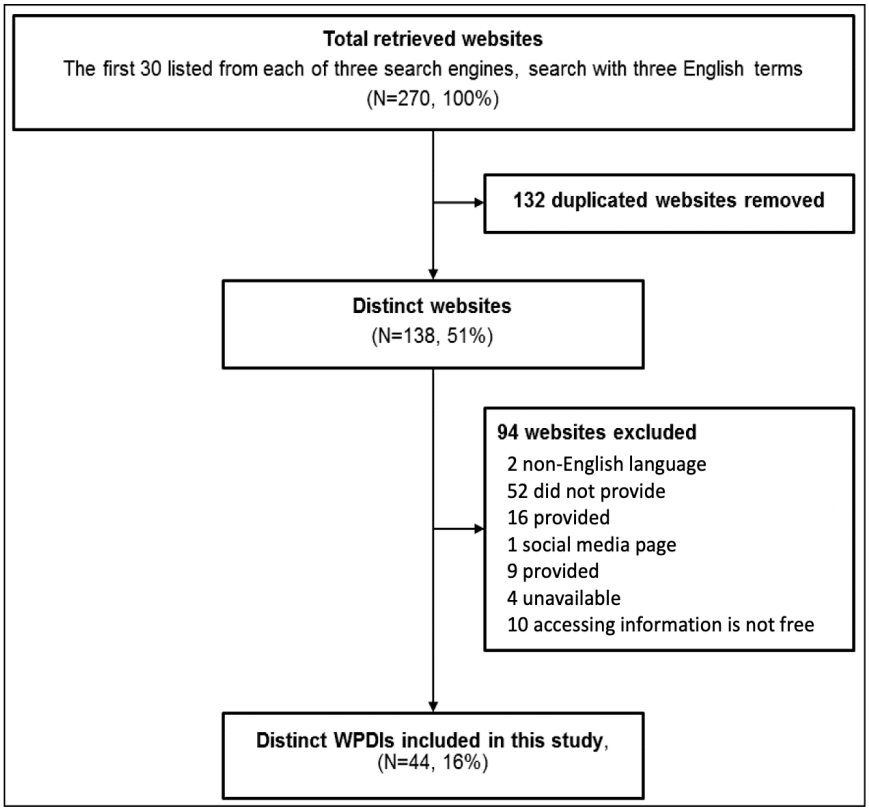

Figure 4. Flow diagram of drug information website recruitment in study (WPDIs: websites providing drug information)

3.4 Reliability of DI-QC

From the previously mentioned 44 websites, 10 drug information websites providing information on amoxicillin were selected for reliability assessment. Ten raters, comprising 5 pharmacists and 5 consumers, were assigned to assess these 10 websites using the DI-QC assessment tool. The reliability of the DI-QC was evaluated in terms of interrater agreement. As detailed in Table 4, 188 pairs of results were calculated for the means of K_w, P_o, P_{index}, B_{index}, and PABAK.

When considering the means of K_w for the 26 items in the pharmacist version, the distribution was as follows: 3 'Good' items (11.54%), 5 'Moderate' items (19.23%), 6 'Fair' items (23.08%), 11 'Slight' items (42.31%), and 1 'Poor' item (3.85%). For the means of K_w of the 26 items in the consumer version, the distribution was: 2 'Moderate'

items (7.69%), 8 'Fair' items (30.77%), 15 'Slight' items (57.69%), and 1 'Poor' item (3.85%). The B_{index} levels for all 52 items ranged from 'Poor' to 'Slight', indicating that none of the K_W values obtained in this study were influenced by bias.

As depicted in Table 4, some items exhibited low means of K_W (<0.41), yet their means of P_{index} ranged from 'Moderate' to 'Very High', indicating that the obtained means of K_W were underestimated. This highlights the paradoxes influencing the magnitude of the kappa coefficients. PABAKs were subsequently examined and all fell within the range of 'Fair' to 'Excellent'. This observation is likely because drug information websites display clear features that align with the criteria for those items, leading raters to inadvertently give them a high prevalence of positive ratings (3–5 points) or negative ratings (1–2 points). Discrepancies can also arise when raters do not strictly adhere to the instructions for each question. Conversely, some items had a high means of K_W (≥0.41), and their means of P_o also ranged from 'Moderate' to 'Very High'. These items fell into a group characterized by genuinely high reliability, making it unnecessary to consider their PABAKs. As noted by Sim and Wright (2005), PABAK, when viewed in isolation, is uninformative as it pertains to a hypothetical scenario where prevalence or bias is absent. However, as suggested by Viera and Garrett (2005), PABAK was presented alongside, rather than in lieu of, the determined kappa values. Therefore, in this study, PABAK was taken into account under certain conditions, such as when a large P_{index} or a significant B_{index} affected the magnitude of a high or low kappa coefficient.

Based on the results of the reliability assessment, the content of the two handbooks was rearranged and adjusted to enhance user understanding.

Table 3. Summary of characteristics of drug information websites

Web Character	Descriptive Characteristics† Frequency (%), n=44
Domain name	
.com	28(63.64)
.org	9(20.45)
.gov	4(9.09)
.net	2(4.55)
.info	1(2.27)
Country	
United States	30(68.18)
Australia	4(9.09)
England	3(6.82)
Canada	2(4.55)
New Zealand	2(4.55)
India	1(2.27)
Ireland	1(2.27)
Pakistan	1(2.27)
drug information separated by the target audience	
Not separated	26(59.09)
Clearly separated	14(31.82)
Unclear separated	4(9.09)
Quality label(s) acquired (n=19)	
Third party accreditation	6(32.00)
Privacy-Security control	9(47.37)
HON (Health On The Net Foundation)	11(57.90)
Other(s)	3(15.79)

3.5 Evaluation of drug information websites

To assess the applicability of the DI-QC, the 44 recruited websites were evaluated using both the pharmacist and consumer versions of the tool. Websites were categorized as Excellent, Good, Fair, Poor, and Very Poor based on their scores. Out of the 44 websites, majority received ratings of 'Good' (38.64% for pharmacists, 34.09% for consumers) and 'Fair' (38.64% for pharmacists, 31.82% for consumers). Moreover, the scores for each section, credibility and quality of content were converted into percentages. For instance, if a website received a score of 30 out of 60 for credibility and 42 out of 70 for quality, it would have a credibility rating of 50% and a quality rating of 60%. Plotting these percentages on a scatter chart categorized the website into one of four areas: 'Area A', 'Area B', 'Area C', or 'Area D', as depicted in Figures 5a and 5b. Each area of the scatter chart represents values of credibility and content quality for the website. Figures 5a (using DI-QC for pharmacists) and 5b (using DI-QC for consumers) provide an overview of where each website falls within the quality areas of the scatter chart post-assessment. 'Area A' comprised 24 websites (54.54%) for pharmacists and 28 websites (63.64%) for consumers. The complete evaluation results for the websites are summarized in Table 5.

Table 4. Summaries of inter-rater agreement among each group of raters

No.	Pharmacist group, mean (SD)					Consumer group, mean (SD)				
	K_w	PABAK	P_o	P_{index}	B_{index}	K_w	PABAK	P_o	P_{index}	B_{index}
1	0.19 (0.27)	0.32 (0.32)	0.36 (0.15)	0.52 (0.27)	0.28 (0.18)	0.09 (.24)	0.92 (.10)	0.49 (.15)	0.96 (0.05)	0.04 (0.05)
2	0.18 (0.32)	0.28 (0.37)	0.23 (0.14)	0.18 (0.06)	0.18 (0.18)	0.29 (.17)	0.32 (.21)	0.37 (.09)	0.48 (0.18)	0.16 (0.15)
3	0.32 (0.32)	0.68 (0.19)	0.60 (0.24)	0.72 (0.13)	0.14 (0.08)	0.01 (.11)	0.52 (.27)	0.31 (.32)	0.72 (0.18)	0.18 (0.12)
4	0.23 (0.39)	0.68 (0.17)	0.61 (0.15)	0.76 (0.13)	0.12 (0.10)	0.01 (.28)	0.24 (.49)	0.40 (.27)	0.56 (0.32)	0.30 (0.27)
5	0.62 (0.14)	0.56 (0.21)	0.53 (0.13)	0.12 (0.09)	0.14 (0.08)	0.23 (.19)	0.12 (.40)	0.32 (.14)	0.38 (0.25)	0.40 (0.23)
6	0.06 (0.19)†	0.80 (0.21)	0.75 (0.15)	0.90 (0.11)	0.08 (0.08)	0.06 (.28)	0.60 (.33)	0.47 (.22)	0.76 (0.21)	0.20 (0.16)
7‡	0.19 (0.23)	0.52 (0.30)	0.34 (0.19)	0.64 (0.22)	0.22 (0.17)	0.01 (.16)	0.56 (.34)	0.52 (.29)	0.76 (0.20)	0.20 (0.17)
8	-0.02 (0.40)	0.32 (0.34)	0.27 (0.20)	0.48 (0.24)	0.24 (0.18)	-0.02 (0.16)	0.52 (.34)	0.50 (.25)	0.72 (0.19)	0.20 (0.13)
9	0.59 (0.18)	0.56 (0.18)	0.44 (0.21)	0.28 (0.15)	0.12 (0.15)	0.19 (.21)	0.04 (.34)	0.31 (.14)	0.30 (0.23)	0.38 (0.21)
10	0.41 (0.26)	0.36 (0.31)	0.44 (0.30)	0.26 (0.15)	0.26 (0.20)	0.29 (.25)	0.16 (.37)	0.34 (.18)	0.30 (0.23)	0.38 (0.21)
11	0.22 (0.25)	0.16 (0.40)	0.21 (0.19)	0.24 (0.13)	0.24 (0.21)	0.26 (.27)	0.08 (.34)	0.26 (.13)	0.26 (0.17)	0.30 (0.25)
12	0.19 (0.27)	0.16 (0.40)	0.23 (0.29)	0.32 (0.23)	0.24 (0.14)	0.24 (.22)	0.12 (.36)	0.29 (.11)	0.32 (0.21)	0.36 (0.21)
13	0.48 (0.25)	0.64 (0.23)	0.45 (0.23)	0.36 (0.13)	0.12 (0.10)	0.16 (0.21)	0.16 (0.32)	0.41 (0.21)	0.36 (0.29)	0.36 (0.20)
14	0.11 (0.20)	0.84 (0.13)	0.32 (0.12)	0.92 (0.06)	0.06 (0.05)	0.13 (0.25)	0.60 (0.19)	0.27 (0.16)	0.72 (0.10)	0.08 (0.10)
15	0.04 (0.33)	0.40 (0.25)	0.31 (0.17)	0.60 (0.12)	0.12 (0.08)	0.01 (0.20)	0.52 (0.62)	0.28 (0.20)	0.76 (0.31)	0.24 (0.31)
16	0.22 (0.25)	0.32 (0.32)	0.30 (0.11)	0.52 (0.24)	0.26 (0.14)	0.02 (0.21)	0.44 (0.37)	0.49 (0.22)	0.68 (0.24)	0.24 (0.18)
17	0.07 (0.17)	0.28 (0.42)	0.25 (0.07)	0.60 (0.22)	0.22 (0.15)	0.03 (0.19)	0.56 (0.34)	0.50 (0.25)	0.76 (0.19)	0.18 (0.15)
18	0.27 (0.28)	0.20 (0.41)	0.32 (0.15)	0.24 (0.16)	0.26 (0.17)	0.23 (0.26)	0.48 (0.25)	0.47 (0.18)	0.60 (0.22)	0.22 (0.15)
19‡	0.72 (0.13)	0.68 (0.14)	0.73 (0.07)	0.32 (0.13)	0.14 (0.08)	0.12 (0.25)	0.36 (0.36)	0.40 (0.17)	0.58 (0.24)	0.22 (0.13)
20	0.18 (0.27)	0.24 (0.42)	0.28 (0.15)	0.56 (0.29)	0.30 (0.19)	0.19 (0.26)	0.60 (0.28)	0.57 (0.31)	0.76 (0.19)	0.18 (0.15)
21	0.43 (0.42)	0.36 (0.40)	0.39 (0.14)	0.14 (0.13)	0.20 (0.12)	0.07 (0.17)	0.16 (0.37)	0.22 (0.17)	0.48 (0.30)	0.32 (0.19)
22	0.47 (0.23)	0.48 (0.30)	0.39 (0.14)	0.22 (0.13)	0.20 (0.16)	0.53 (0.20)	0.51 (0.25)	0.48 (0.29)	0.44 (0.19)	0.20 (0.12)
23‡	0.13 (0.22)	0.44 (0.35)	0.26 (0.20)	0.68 (0.21)	0.22 (0.14)	0.35 (0.36)	0.67 (0.31)	0.59 (0.17)	0.71 (0.18)	0.16 (0.15)
24	0.64 (0.16)	0.56 (0.21)	0.58 (0.10)	0.20 (0.08)	0.08 (0.06)	0.49 (0.20)	0.60 (0.21)	0.45 (0.24)	0.40 (0.18)	0.20 (0.11)
25	0.21 (0.26)	0.08 (0.41)	0.20 (0.19)	0.28 (0.21)	0.30 (0.21)	0.24 (0.23)	0.48 (0.39)	0.31 (0.19)	0.72 (0.18)	0.16 (0.15)
26	0.14 (0.34)	0.00 (0.35)	0.18 (0.11)	0.24 (0.16)	0.26 (0.17)	0.02 (0.21)	0.24 (0.37)	0.26 (0.11)	0.52 (0.23)	0.24 (0.14)

Note: † Individual K_w score from one pair of raters was excluded due to being inapplicable ($K_w=\infty$), ‡One pharmacist rater missed one rating result

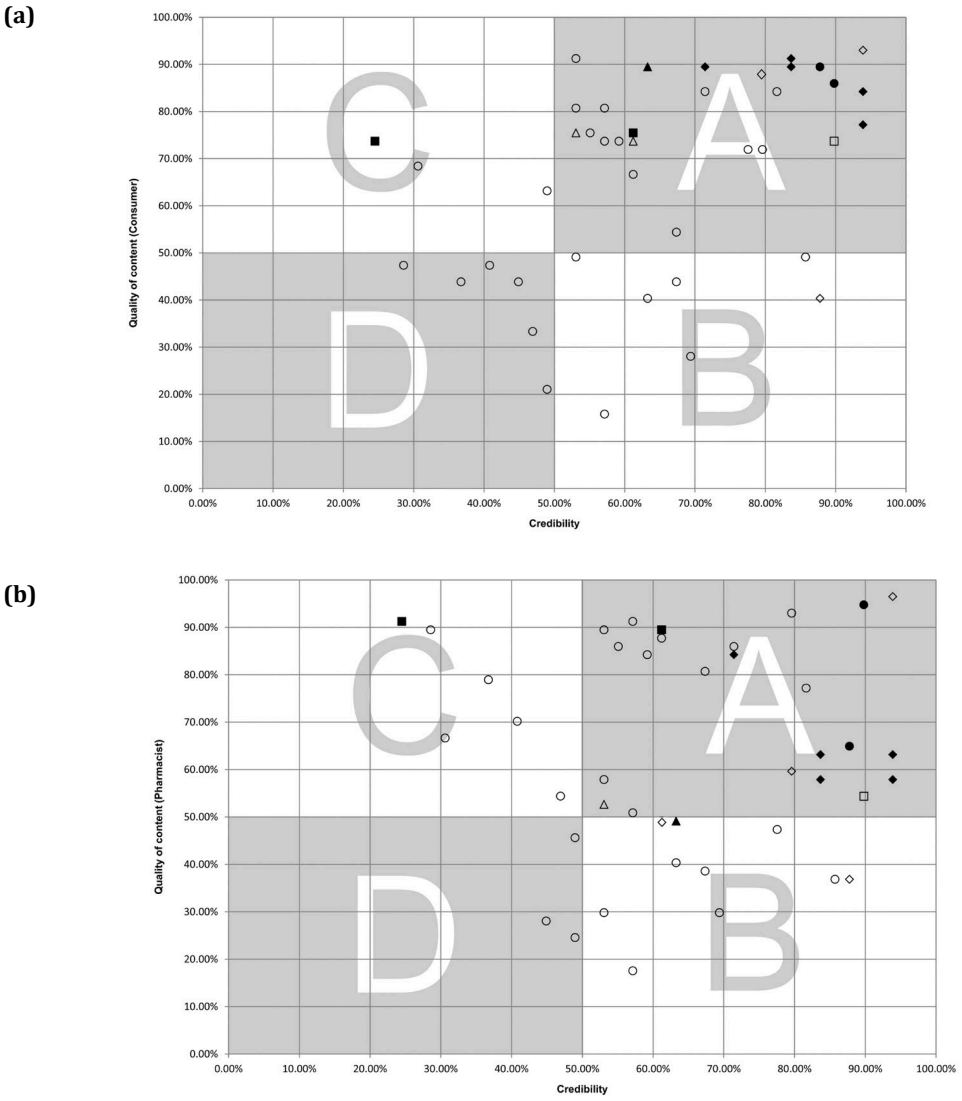

Figure 5. Overview (scatter plot) of drug information websites as evaluated using (a) DI-QC for pharmacists and (b) DI-QC for consumers (◆ website with HON label, ▲ website with privacy-security control label, ■ website with third-party certification, □ website with HON label and privacy-security control label, ◇ website with HON label and third-party certification, △ website privacy-security control label and third-party certification, ● website with HON label, privacy-security control label, and third-party certification, ○ website without special label or certification)

Table 5. Summarized numbers of websites classified by assessment scores (evaluation results) and area allocation, using both DI-QC for pharmacists and consumers

Evaluation results	Area allocation, frequencies (%), using pharmacist / consumer version				Total
	Area A	Area B	Area C	Area D	
Excellent	4(9.1) / 7(15.9)	-	-	-	4(9.1) / 7(15.9)
Good	17(38.6) / 15(34.1)	-	-	-	17(38.6) / 15(34.1)
Fair	3(6.8) / 6(13.6)	8(18.2) / 5(11.4)	6(13.6) / 3(6.8)	-	17(38.6) / 14(31.9)
Poor	-	3(6.8) / 2(45.5)	-	3(6.8) / 6(13.6)	6(13.6) / 8(18.2)
Very Poor	-	-	-	-	0(.00) / 0(.00)
Total	24(54.5) / 28(63.6)	11(25.0) / 7(15.9)	6(13.6) / 3(6.8)	3(6.8) / 6(13.6)	44(100.0) / 44(100.0)

As summarized in Table 5, 'Area A' in both charts includes a mix of drug information websites rated from 'Fair' to 'Excellent'. In contrast, drug information websites rated as 'Good' to 'Excellent' were all positioned in 'Area A', while those rated as 'Fair' were scattered across 'Area A', 'Area B', and 'Area C'. These findings suggest that interpreting the evaluation results from DI-QC may require a dual approach, comparing ranges of total scores and analyzing the two dimensions separately. The use of scatter charts can provide deeper insights into user decisions, both from visitors and website developers, facilitating a more thorough evaluation of drug information websites, especially for those with ratings lower than 'Fair'.

Malone et al. stated that "There is a variety of health information sources, and the quality of information provided varies greatly. Consumers can consult these sources, but some may not be appropriate or helpful" (Malone et al., 2012). This observation aligns with the results shown in Figures 5a and 5b, illustrating the diverse nature of websites. Visitors may encounter risks when relying on drug information websites that appear trustworthy or of high quality. This is due to the perilous nature of the Internet, where inaccurate, misleading, and potentially harmful information can be found. Consumers lacking skills or awareness about information quality, may misinterpret information, leading to confusion, misinformation, or being misled (Ghoshal and Walji, 2006).

In addition to the user guidance tool DI-QC, the HON quality label, eTrusty, and URAC also guide users toward reputable websites (Wilson, 2002). Kaicker et al. found that websites with health-related seals of approval tend to have higher DISCERN scores (Kaicker et al., 2010). In this study, as illustrated in Figures 5a and 5b, we observed that 90.91% of the drug information websites, displaying HON labels were in 'Area A', with the remainder in 'Area B', suggesting high credibility (>70%). However, Morel et al. argued that the HON label might not effectively predict content quality or website affiliations (Morel et al., 2008). Drug information websites with quality labels for privacy-security control consistently received 5 points for the question 'Does it have good confidentiality?' (as referenced in Table 1, No. 3). Conversely, the credibility of drug information websites with third-party certifications was also notably high, possibly due to these agencies offering services in a various accreditation programs beyond website accreditation (as seen in Figure 5). These findings suggest that while a quality label like HON may serve as a primary indicator of a drug information website's overall credibility, further investigation is warranted for other seals of approval to determine the range of quality service they endorse.

Overall, DI-QC exhibited commendable validity and reliability. The website evaluation results using DI-QC showed that the assessment tool was functional and practical. However, as it is intended as a user-guidance assessment tool, resulting scores are subjective, and no definite cutoff exists to determine a specific quality level. Users must make individual decision about the website's worthiness.

A methodological limitation to consider is that the reliability assessment was conducted with only 10 websites, which met the minimum requirement for the inter-rater agreement test as recommended by Washington and Moss (1988). Therefore, further studies should be conducted with an increased number of raters and websites to enhance the reliability of the assessment. Since DI-QC focuses on evaluating credibility and content quality, other existing user guidance tools should be employed concurrently to assess other dimensions of websites. Additionally, users should study and adhere to the usage guidelines provided in the DI-QC handbooks.

4. CONCLUSIONS

The DI-QC assessment tool has been developed through reliable processes, offering users with the means to evaluate the credibility and quality of drug information websites. It also informs user about which websites are acceptable as drug information resources. The evaluation results from DI-QC offer valuable insights for decision-making, allowing separate analyses of credibility and content quality. This tool proves particularly beneficial for assessing drug information websites with a total rating score of less than 'Fair'.

ACKNOWLEDGMENT

We would like to thank Asst. Prof. Perayot Pamonsinlapatham, Asst. Prof. Raksaworn Jaisaard, and Asst. Prof. Waranee Bunchuailua for content validity testing. Special thanks to John Tigue for reviewing the English language. We are deeply grateful to all the participants in the tool reliability assessment. This study was partially supported by a grant for graduate students from the Research and Creative Fund at the Faculty of Pharmacy, Silpakorn University.

REFERENCES

Bernstam, E. V., Shelton, D. M., Walji, M., and Meric-Bernstam, F. (2005). Instruments to assess the quality of health information on the World Wide Web: What can our patients actually use? *International Journal of Medical Informatics*, 74(1), 13–19.

Charnock D., Shepperd S., Needham G., and Gann R. (1999). DISCERN: An instrument for judging the quality of written consumer health information on treatment choices. *Journal of Epidemiology and Community Health*. 53(2), 105–111.

Cline R. J., and Haynes, K. M. (2001). Consumer health information seeking on the Internet: The state of the art. *Health Education Research*. 16(6), 671–692.

Cunningham, M. (2009). *More than just the kappa coefficient: A program to fully characterize inter-rater reliability between two raters (Statistics and Data Analysis, Paper 242-2009),* SAS Global Forum 2009. [online URL: support.sas.com/resources/papers/proceedings09/242-2009.pdf] accessed on June 24 2022.

Darmoni, S. J., Leroux, V., Daigne, M., Thirion, B., Santamaria, P., Duvaux, C., and Gea, M. (1999). Net scoring: Critères de qualité de l'information de santé sur l'Internet. *Technologie Santé*. 36, 128–142.

Fox, S., and Syndey, J. (2009). *The social life of health information.* Pew Research Center. [Online URL: pewresearch.org/internet/2009/06/11/the-social-life-of-health-information/] accessed on April 5, 2022.

Ghoshal, M., and Walji, M. F. (2006) Quality of medication information available on retail pharmacy web sites. *Research in Social Administrative Pharmacy*, 2(4), 479–498.

Hardman, J. G., Limbird, L. E., and Gilman A. G. (Eds). (2001). *Goodman & Gilman's: The Pharmacological Basis of Therapeutics*, 10th, NY: McGraw-Hill.

Health On the Net Foundation. (2020). *HONcode certification*. [Online URL: https.//www.hon.ch/en/certification.html] accessed on August 10, 2023.

Internet Lives Stats. (2016). *Internet users*. [Online URL: internetlivestats.com/internet-users/] accessed on April 5, 2022.

Jadad, A. R., and Gagliardi, A. (1998). Rating health information on the internet: Navigating to knowledge or to Babel? *JAMA*, 279 (8), 611–614.

Kaicker, J., Borg Debono, V., Dang, W., Buckley, N., and Thabane, L. (2010). Assessment of the quality and variability of health information on chronic pain websites using the DISCERN instrument. *BMC Medicine*, 8, 59.

Kim, P., Eng, T. R., Deering, M. J., and Maxfield, A. (1999). Published criteria for evaluating health related web sites: Review. *BMJ*, 318(7184), 647–649.

Kim, K. Y., Metzger, A., Wigel, P. R., and Choe, P. J. (2011). Evaluation of online consumer medication information. *Research in Social and Administrative Pharmacy*, 7(2), 202–207.

Landis, J. R., and Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1), 159–174.

Joseph, L. C. (2015). *Web Evaluation*. Cyberbee. [Online URL: cyberbee.com/guides_sites.html] accessed on September 6, 2022.

Luk, A., and Aslani, P. (2011). Tools used to evaluate written medicine and health information: Document and user perspectives. *Health Education Behavior*, 38(4), 389–403.

Malone, P., Kier, K., and Stanovich, J. (2012). *Drug Information: A Guide for Pharmacists*, 4th, NY: McGraw-Hill.

Martin-Facklam, M., Kostrzewa, M., Schubert, F., Gasse, C., and Haefeli, W. E. (2002). Quality markers of drug information on the internet: An evaluation of sites on St. John's Wort. *The American Journal of Medicine*, 113(9), 740–745.

Minervation. (2008). *The LIDA Instrument Minervation validation instrument for health care web sites, version 1.2*. [Online https://www.minervation.com/wp-content/uploads/2011/04/Minervation-LIDA-instrument-v1-2.pdf] accessed September 6, 2022.

Morel, V., Chatton, A., Cochand, S., Zullino, D., and Khazaal, Y. (2008). Quality of web-based information on bipolar disorder. *Journal of Affective Disorders*, 110(3), 265–269.

Nasser, S., Mullan, J., and Bajorek, B. (2012). Assessing the quality, suitability and readability of internet-based health information about warfarin for patients. *Australasian Medical Journal*, 5(3), 194–203.

Polit, D. F., and Beck, C. T. (2006). The content validity index: Are you sure you know what's being reported? critique and recommendations. *Research in Nursing & Health*, 29(5), 489–497.

Rao, N. R., Mohapatra, M., Mishra, S., and Joshi, A. (2012). Evaluation of dengue-related health information on the internet. *Perspective in Health Information Management*, 9(Summer), 1c.

Rees, C. E., Ford, J. E., and Sheard, C. E. (2002). Evaluating the reliability of DISCERN: a tool for assessing the quality of written patient information on treatment choices. *Patient Education and Counseling*, 47(3), 273–275.

Robert Sabaté, L., and Diego, L. (2021). Are we offering patients the right medicines information? A retrospective evaluation of readability and quality in online patient drug information. *European Journal of Hospital Pharmacy*, 28, 144–148.

Silberg, W. M., Lundberg, G. D., Musacchio, R. A. (1997). Assessing, controlling, and assuring the quality of medical information on the internet. *Journal of the American Medical Association*, 277, 1244–1245.

Sim, J. and Wright, C. C. (2005). The kappa statistic in reliability studies: Use, interpretation, and sample size requirements. *Physical Therapy*, 85(3), 257–268.

Viera, A. J., and Garrett, J. M. (2005). Understanding interobserver agreement: the kappa statistic. *Family Medicine*, 37(5), 360–363.

Washington, C. C., and Moss, M. (1988). Pragmatic aspects of establishing interrater reliability in research. *Nursing Research*, 37(3), 190–191.

Wilson, P. (2002). How to find the good and avoid the bad or ugly: a short guide to tools for rating quality of health information on the internet. *British Medical Journal*, 324(7337): 598–602.

Yap, K. Y.-L., Raaj, S., and Chan, A. (2010). OncoRx-IQ: A tool for quality assessment of online anticancer drug interactions. *International Journal of Quality in Health Care*, 22(2), 93–106.

Supplement 1 List of drug information websites assessed in the study

Name	URL
American Academy of Allergy, Asthma & Immunology (AAAAI)	www.aaaai.org
About health	www.about.com/health
Allergan	www.allergan.com
Australian Rheumatology Association (ARA)	www.rheumatology.org.au
Arthritis	www.arthritis.org
Bristol-Mayers Squibb	www.bms.com/pages/default.aspx
CVS/Caremark[tm]	www.caremark.com/wps/portal
Centerwatch	www.centerwatch.com
Drugalert	www.drugalert.org
Druginformation	www.druginformation.com
Druginfosys	www.druginfosys.com
Drugs †	www.drugs.com
Drugwatch	www.drugwatch.com
Epilepsy	www.epilepsy.com
Express-scripts	www.express-scripts.com/frontend/content/#/drugsearch
Drug@fdadatabase	www.fda.gov
Gilead	www.gilead.com
Healthline	www.healthline.com
HIVmedicationguide	www.hivmedicationguide.com
Humana	www.humana.com
Iodine †	www.iodine.com
Mayoclinic †	www.mayoclinic.org
Medbroadcast	www.medbroadcast.com
Medicinenet	www.medicinenet.com/script/main/hp.asp
Medicineonline	www.medicineonline.com
Medicines (EMC)	www.medicines.org.uk/emc
Medicines (AU) †	www.medicines.org.au
Medilexicon	www.medilexicon.com/drugsearch.php
MedIndia †	www.medindia.net
Medsafe	www.medsafe.govt.nz
Merck	www.merck.com
National Alliance on Mental Illness (NAMI)	www.nami.org
Novartis	www.pharma.us.novartis.com/index.jsp
Medlineplus †	www.nlm.nih.gov/medlineplus
NPS MedicineWise	www.nps.org.au
Patient †	www.patient.info
PDR †	www.pdr.net
Riteaid †	www.riteaid.com
Rxlist †	www.rxlist.com
Safemedication	www.safemedication.com
Therapeutic Goods Administration	www.tga.gov.au
Vytorin®	www.vytorin.com
Walgreens	www.walgreens.com
Webmd	www.webmd.com