Exploring the impact of medical knowledge and information search skills on information searching behavior and quality of information found: A study comparing students-residents in medicine versus students in computer science

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Abstract

Background: Nowadays, Internet has become the primary source of information for physicians seeking answers to medical questions about their patients before consulting colleagues. However, many websites display information of low quality, less reliability, and lack scientific verification. Therefore, physicians need to develop information search skills to locate relevant and evidence-based information. However, previous studies have shown that physicians often have poor search skills and encounter difficulties in finding information on the Web. These challenges may have detrimental consequences on patient care.

Objective: The present study aims to determine how medical students-residents search for medical information on Internet, what quality of web resources they utilize (including the nature and credibility of resources), and how they evaluate the reliability of web resources and the answers they provide. Given the importance of domain knowledge (in this case, medicine) and information search skills to the search activity, we compared the search behaviors of medical students and residents to those of students in computer science. Medical students-residents typically possess higher medical-related knowledge, while students in computer science generally have information search skills.

Methods: Twenty students participated in this study: ten medical students-residents and ten students in computer science. Data were extracted from a freely accessible dataset. All participants were tasked with searching for information on the web to make a medical diagnosis, select a treatment, and enhance their knowledge of a medical condition—three primary activities they engage in online. We analyzed search performance metrics (such as search time, medical-related keywords used, and accuracy of information found) as well as the nature and credibility of web resources utilized by medical students and residents compared to students in computer science.

Results: Students-residents in medicine provided, in mean, more accurate answers than students in computer science, all without requiring additional time. Their background in medicine also enabled them to better evaluate the reliability of resources and select high-quality web resources more effectively than students in computer science, primarily from hospital websites. However, it is noteworthy that students-residents in medicine utilized very few evidence-based tools, such as PubMed.

Conclusions: Although that students-residents in medicine had in general high performance than students in computer science, they did not use frequently evidence-based tools. As previously observed students-residents may avoid using databases due to the risk of encountering too many irrelevant articles and difficulties in applying correct filters to locate relevant information. Nevertheless, clinical and practical evidence-based medicine can significantly contribute to updating physicians' knowledge, improving patient care, and enhancing physician-patient relationships. Therefore, information search should be an integral part of medical training programs and continuing medical education for physicians.

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Keywords: Information searching; Credibility; Internet; Medicine; Information Search skills

Introduction

Nowadays, information searching on the Web is an integral part of a physician's professional activity. While in 2006, Bennett et al. [1] showed that the first source of information was colleagues, more recently, the Internet has become the primary source of information before consulting colleagues when physicians have medical questions about patients [2,3].

When information searching activity is conducted efficiently, it has various positive outcomes for physicians and, by extension, their patients [2]. Indeed, appropriate information searching by physicians may improve patient care [4,5], clinical decision-making [5] and physicians' knowledge [5,6]. It also reduces delays in diagnosis, initiation of treatment, modification of treatment [5], as well as potential medical errors and unnecessary medical exams [6].

More precisely, Bennett et al. [1] highlighted that physicians, especially younger ones, use the Internet and conduct searches in order to: (1) find information and solutions to specific patient diagnostic issues (from 33.7% to 57% of respondents according to studies); (2) obtain new information on diseases (20.4%); (3) stay informed on the latest research about precise topics and general matters (e.g., disease, 27%; new therapies and treatments, 8.8%; drug dosing information, 5.6%; also shown [7,8,9]).

Concerning information related to treatment and diagnosis, Daei et al. [2] indicated that physicians need from 2 to 32 minutes to find answers on the Internet, depending on the nature of the information to be found (e.g., side effects, drug dosing, new therapies). Nevertheless, in most studies, physicians spend less than 10 minutes finding answers and less than 2 minutes during patient consultations [2]. During consultations, physicians search for information on drug dosing and its potential side effects or to show images to patients [10].

Although physicians indicated that they find information in the majority of cases (more than 50% of information searches for 70% of physicians), and more than 60% of them were confident in finding the information they needed on the Internet [2], physicians experience various difficulties and barriers in information searching. For instance, a survey of general practitioners carried out by [11] has shown that the main obstacles were related to the lack of specific knowledge or skills of physicians, clinical practice conditions (lack of time, patient relations concerns), information (information overload, quality concerns, low relevance), and language barriers. It is noteworthy that on occasion, reliance on Internet-supplied information can result in clinical errors, with physicians responding to and processing such information even when it contradicts their pre-existing knowledge [12], even when sometimes their prior knowledge elements were accurate. It is emphasized that while the use of web resources can improve physicians’ clinical decisions [6], there is a potential for occasional discrepancies leading to errors in the decision-making process related to the quality and reliability of information found. Outpatient diagnostic error rates have been estimated at 5%, affecting more than 12 million individuals per year, whereas inpatient diagnostic errors range from 6 to 7%, and 20% of initial diagnoses are modified [13]. An efficient use of information access systems (e.g., search engines) may positively impact patient care, but the reverse can happen if the Internet is misused. Therefore, it is very important that physicians and medical students develop accurate information search skills[1] to use these systems according to the specificities related to the medical domain.

Previous studies have reported a lack of information search skills, requiring technical support to search for information [1], unawareness of accessible sources [2], difficulties in accessing reliable and up-to-date medical information, and challenges in developing efficient search strategies [4]. Additionally, on the Internet, physicians face the challenge of processing a significant amount of information in a very short time [14]. Previous works have shown that well-designed, easy-to-navigate websites are usually perceived as more reliable than those with a confusing or complicated interface [15], and the first websites provided by search engine tools have been perceived as more credible [16]. However, well-designed websites or the first search engine results are not enough to confirm that the information contained therein is credible and reliable. The Internet displays a variety of medical-related information content, which is not all verified and reliable (e.g., [17] for a study showing that only 58% of e-health websites in the U.S. met the criteria of content accuracy and credibility). Physicians need documents that are more reliable and relevant to their practice in order to integrate them into clinical practice. Consequently, they have to develop information search skills to be able to find and assess web resources in addition to medical-related knowledge.

Moreover, there is an institutionalized perception that the information found does not significantly enhance their medical practice [6] – for a comprehensive review, see [2]. This perception may be partially attributed to the fact that not all physicians are aware that evidence-based medical resources of information are available on the Internet (e.g., PubMed) and may lack the search skills to access these resources [18].

In order to effectively improve information search skills in the medical domain, it is important to understand how medical students search for information in their domain during their university program. In a study conducted with medical students, [19] showed that students searched for online medical and clinical information daily (2-3 times a day). They used many websites (more than 50), including some recommended by the NHS, such as PubMed (only 30% of physicians and 8% of all their searches). However, they also used many other general websites, such as Wikipedia (71% of them and 26% of searches), patient forums, or medical-specific wikis, and Google (79% of them or 32% of all searches). Indeed, Google is the most widely used general web search engine, and it has become an important tool in physicians' searches. Nevertheless, this search engine is not specialized in medical-related information, and various websites provide medical-related information without being curated by scientists and/or physicians[20,21]. Therefore, physicians have to assess the quality of the information obtained on the websites they opened, and it is frequently observed that physicians and medical students use Google rather than medicine-specific databases to find answers to clinical questions [22]. For instance, [22] provided clinical questions to residents in the emergency department and asked them to search for answers with a search engine (here, Google) or without it (they searched for information in a real environment). The results showed that the number of incorrect answers increased whereas unsure answers decreased with Google versus without Google. The residents had a false sense of reliability in their answers and ultimately poor efficiency in searching for and finding correct clinical information with Google. Google may be considered an evidence-based medical tool by students and physicians, but it is not specifically an evidence-based medical database (e.g., PubMed).

Based on these prior works, we can assert that medical-related information available on the Internet supports clinical decision-making about patient healthcare, on the condition that physicians and medical students are trained to evaluate the quality of sources and content of medical-related information they deal with on the Internet. The quality of medical-related information used can be assessed according to two dimensions: (1) Credibility of sources pertains to the degree of trustworthiness associated with information and its origin [23,24,25,26]. This encompasses

[1] Information search skills correspond to procedural knowledge about tools to be used for finding information (e.g. Google, PubMed, etc.).

assessments of accuracy, authority, objectivity, currency, and coverage [27,25]. Credibility is almost inseparable and closely related to trustworthiness, reliability, accuracy, authority, and quality [23,24,28]. So, in general, credibility may impact the reliability of information. Reliability refers to the extent to which information can be considered consistent and trustworthy under similar circumstances [29,30].

In the medical domain, [6] distinguished credible documents as follows: (1) authoritative web documents such as scientific digital databases (e.g., PubMed), websites of medical communities (e.g., European Society of Cardiology), online peer-reviewed scientific journals (e.g., The Lancet, JAMA), specialized medical journals (e.g., Circulation, Heart), electronic books, and government agency websites (e.g., Public Health Administration, Food & Drug Administration); (2) non-authoritative web documents such as medical portals, personal websites of physicians, pharmaceutical company websites, social media, and medical equipment websites. The authoritative sources can be considered credible and reliable, while the non-authoritative sources require in-depth evaluation to determine their level of credibility and reliability. Therefore, when physicians and medical students use general websites to find medical-related information, they must both:

1. Convert a clinical or medical question/need into a search strategy to find reliable information. This activity requires using specific medical terms and then choosing credible websites and/or scientific databases.
2. Assess credibility, reliability, relevance, and accessibility cues to choose the web resources they consult and use (see the review by [2]).

These two activities can be very complex, especially when general-purpose search engines (e.g., Google) are used since they must choose appropriate keywords and credible websites to find reliable information relevant to their professional objectives. This information-searching activity could be more difficult for medical students and residents since they have less medical knowledge and practice than senior physicians. Additionally, medical students and residents are not specialists in information systems with search access systems; they lack procedural knowledge (i.e., information search skills). In contrast, computer science students and especially those in information systems are specialized in information search on the Internet [31]; they have high information search skills (procedural knowledge) but very little or no medical-related knowledge.

Previous works have underlined that physicians and medical students lack information search skills but have medical-related knowledge. Therefore, it is relevant to compare their information search behaviors with those of computer science students. Indeed, computer science students have higher information search skills than medical students and residents, so their comparison will allow identifying with greater precision the difficulties experienced by medical students and residents during their information searches on the Internet due to their lack of procedural skills. Additionally, since prior domain knowledge (e.g., [32]) is known to support information searching activity, we can simultaneously identify its positive effects on medical information searching. We argue that it is challenging to focus on medical students and residents, future physicians, to understand the ways and possible difficulties they search for information, the web resources they use, and how they assess the reliability of these documents to consider these points during their university training.

Most prior works that have looked at how physicians search for information used interviews or questionnaires to determine how they look for information [2]. Very few have studied the actual activity of physicians or students, even though it is crucial to identify precisely how they use the web in the face of searches they may be required to make. To contribute to this topic, we carried out an experimental study in which medical students and residents had to search for information on the web. More precisely, the current study aimed to determine if prior knowledge in medicine allowed medical students and residents to obtain higher search performance and make better choices regarding reliable resources than computer science students who were experienced in information search and had higher information search skills. More precisely, this study aimed to bring some elements of answers to the following research questions:

RQ1. Do the most popular searches developed by physicians, i.e., treatment, diagnosis, and learning on a specific medical topic, lead to different search performance between computer science students (with higher information search skills but lower medical knowledge) and medical students and residents (with higher medical knowledge but lower information search skills)?
RQ2. What resources and their level of credibility do they consult when they perform medical search tasks, and with regard to their knowledge?
RQ3. Do they assess differently the reliability of sources they choose to use and the quality of answers they provide for the search task to be performed?

Methods

Participants

The free access dataset used in this study was extracted from a user study conducted by [33].
Twenty students from the University of Toulouse participated at this study:

- 10 students-residents in medicine: 5 females and 5 males (M_{age}=25.4 year-old, SD=3.1). Two were in master degree and eight in MD degree.
- 10 students in computer science: 4 females and 6 males (M_{age}=23.8 year-old, SD=1.5). Five students were in master degree and five in PhD degree.

To evaluate the level of knowledge in medicine and their familiarity with Internet, all the participants had:

- To self-evaluate their knowledge in medicine, on a 5-point Likert scale ranging from 1 (very low) to 5 (very high). The students in medicine self-evaluated higher their level of knowledge in medicine than the students in computer science (M_{med}=4.2, SD=.63; M_{cs}=1.3, SD=.48; $t(18)=-11.5$, $p<.001$, d=-5.15).
- To complete multiple-choice questionnaire in the Medicine domain, which consisted of 10 questions, each with five response options (one correct, three incorrect, and "I don't know"). This multiple-choice questionnaire was elaborated by a physician. Only correct answers earned a point, so the score per participant could range from 0 to 10. Results indicated that students-residents in medicine scored significantly higher (M=5, SD=0.66) than students in computer science did (M=0.5, SD=.97) ($t(18) = -12.1$, $p < .001$, d = -5.4).
- To complete the Information search Self-Efficacy Scale developed by [34], to indicate the number of years of Internet use and the contexts of use. Results showed that students in computer science (M=4.4, SD=.51) had higher score of IS self-efficacy than those in medicine (M=3.1, SD=.73) ($t(18) = 4.56$, $p < .001$, d = 2.04), but they did not significantly differ on the number of years of use the Internet ($t(18) = -1.61$, $p > .1$, d = -0.721; M_{CS}=12.3, SD_{CS}=1.83 and M_{med}=14, SD_{med}=2.79). All the participants indicated they used Internet for their university and personal objectives.

Procedure and material

Firstly, all participants completed an online prequestionnaire containing a free and informed consent form, questions about sociodemographic variables (e.g. age, sex, level of education, native language), the Internet information search scales, and the multiple-choice questionnaires assessing level of knowledge in medicine. It was also in this prequestionnaire that participants described their general Internet habits (i.e. browsing support used, browser and search engine used) and Information search Self-Efficacy Scale [34].
Then, the participants had to perform the experiment at home. The experimental materials were as follows:

- A printed booklet containing the general instructions to be followed throughout the experiment, a training exercise for using our logging browser, the statements for the search tasks, and spaces in which to write the answers. As the written production task was pencil and paper, the computer was only used for the search sessions.
- A memory stick containing the browser was used for the search sessions, allowing participants to directly search for data when reviewing the experimental material.

In the instructions, it was clearly specified that the answer for each task had to be written after the search session (i.e., after closing the browser). There was no time limit. No note-taking was allowed during the search session, to ensure that the answer corresponded as closely as possible to the level of knowledge stored in participants' memory.
Three different search tasks in general medicine were provided to the participants (students-residents in general medicine and student in computer science) (see Table 1 for search tasks to be performed). These tasks looked like to real tasks that physicians and students in medicine do, i.e. to improve their knowledge in a disease area, search for information about a specific patient problem, to decide and choose the most appropriate treatment for patients [2,1].

Table 1. The three different tasks provided to the participants and correct answers.

Three different tasks and answers	**Tasks' instructions**	**Sub-tasks required**
<u>Learning task:</u> improving knowledge on a specific area/disease No correct answer, but the productions of participants were analyzed in order to computer the number of elements they provided	You want to learn more about endometriosis.	1. Understanding endometriosis 2. Understand the issues related to endometriosis 3. Discover/learn more about medical solutions to treat endometriosis
<u>Treatment decision task:</u> Choosing the most appropriate treatment Correct answer: anticoagulant treatment (because the old woman did not fall too many times for her age)	An 83-year-old woman had a non-sequelae stroke 5 months ago. At the stroke assessment, atrial fibrillation was discovered. She had dropped 3 times in the last 2 months. Should anticoagulant therapy be initiated? After having evaluated the benefit-risk ratio of the initiation or not of an anticoagulant treatment, select the management that seems best to you and justify your choices	1. Understanding non-sequential stroke 2. Understanding atrial fibrillation 3. Understanding the risk of falls 4. Identify the advantages and disadvantages of anticoagulant therapy 5. Judge this information according to criteria to be established (benefit/risk assessment)

Diagnosis task: Determining the pathology Correct answer: Splenic infarction or spleen infarction	A 47-year-old man presented to the emergency room with left hypochondrium pain that had been evolving for 24 hours and was not relieved by level 1 analgesics. His history included cutaneous lupus and polycythemia. The biological workup was normal. The abdomino-pelvic scanner found two splenic hypodensities. With the information collected on the Internet, propose your diagnosis and etiological hypotheses	1. Understanding the left hypochondrium 2. Understanding of level 1 analgesics 3. Understanding cutaneous lupus and polycythemia 4. Understanding splenic hypodensity 5. Analyze the information previously collected and propose a diagnosis with etiological hypotheses

Variables

Two independent variables (IV) were manipulated:
IV1, domain expertise of participants (or type of knowledge): students-residents in general medicine versus students in computer sciences as between-subject variable.
IV2, search tasks: learning, choosing treatment, diagnostic as within-subject variable.

Six dependent variables (DV) were measured to bring some answers to the three research questions.
For RQ1, we measured three dependent variables:
DV1. Total time of the search session was calculated from the first query produced to the end of the multi query for each search task (expressed in sec.).
DV2. Keywords related to medicine generated by participants. These keywords concern only keywords added to those provided in search task instructions.
DV3. Correct information found for diagnostic and treatment tasks (0 for uncorrected answer or give up and 1 for correct one) and number of relevant information provided by participants for learning task (from 0 to 4 points). Relevant information concerned information related to the topic to be dealt with (here, endometriosis) with regard to the information context [35].
For RQ2, we measured:
DV4. Score of credibility of websites consulted by task (DV4a) and repartition of type of websites and/or documents consulted (DV4b).
For DV4a, we scored the web documents consulted per search task as follows (in line with [6]:

- Peer-scientific journals or scientific databases (e.g. Pubmed, Sciencedirect, The Lancet) = 2 points per URL
- Documents provided by hospitals, health authorities (e.g. WHO), government agencies = 1,5 point per URL
- Health-related websites verified by HONcode[2] = 1 point per URL
- Other websites (not scientifically verified) = 0 point

[2] Fondation Health On the Net (https://www.hon.ch) is a Swiss non-governmental, non-profit foundation. HonCode awards certifications to health-related sites in terms of source reliability.

For DV4b, we analyzed the repartition of documents consulted (peer-scientific journals, documents of hospitals, websites certificated HONcode, other ones) during each search task. This repartition corresponded to the number of resources/documents consulted by categories of documents (related to DV4a) and search tasks.
For RQ3, two dependent variables were measured:
DV5. Self-assessment of reliability of web documents visited while achieving the search task [36]: “Overall, the search engine results, websites and/or documents (results from Google, websites, pdf, etc.) consulted were: (1) absolutely not trustworthy, (2) very untrustworthy, (3) not very trustworthy, (4) moderately trustworthy, (5) somewhat trustworthy, (6) trustworthy or (7) extremely trustworthy. The higher score was, the more participants thought web documents were reliable.
DV6. Self-assessment of their own answers’ quality provided on 4 point-scale for the three tasks. Participants had to indicate his/her perception of answer quality (“I think the answer I provided is: very bad (1) to very good (4)). The higher score was, the more participants considered their answers as good.

Results
For all dependent variables, we compared students-residents in medicine with students in computer science for each task. Some quantitative results are illustrated with qualitative examples.
For all DVs, except DV4b, we performed Student’s t tests. For the DV4b, we computed repeated ANOVA. Tests of homogeneity of variance (Levene test) and normality (Shapiro test) were applied before the ANOVAs and the T-tests. Partial η^2 was used as an index of the relative effect size.
The results are presented according to the three research questions.

Table 2 sets out the means and standard deviations for all dependent variables according to search tasks to be performed by students-residents in medicine and students in computer science.

Table 2. All measures with regard to the search task and expertise domain (means and standard deviations).

Dependent variables	Group of students	Learning task		Diagnostic task		Treatment task	
		M	SD	M	SD	M	SD
DV1. Search time (sec.)	Medicine	548	474	705	444	634	407
	Computer Science	520	373	1099	1085	936	699
DV2. New keywords related to medicine (mean number)	Medicine	1.80	0.91	4	4.19	4.8	4.13
	Computer Science	0.3	0.48	2	2.35	2.7	3.97
DV3. Correct answers or relevant information provided	Medicine	3.9	.31	0.9	0.31	0.85	0.15
	Computer Science	3.5	.52	0	0	0.1	0.31
DV4. Credibility score of	Medicine	5.85	4.37	13.4	9.63	6.9	4.67
	Computer	2.20	2	8	6.53	5.4	4.09

websites consulted	Science						
DV5. Self-assessment of resource reliability consulted (7 point-scale)	Medicine	6.8	0.42	6	0.66	5.4	0.51
	Computer Science	5.8	0.91	5.6	1.07	5.1	0.56
DV6. Self-assessment of quality of answer (4 point-scale)	Medicine	1.84	0.14	1.73	0.13	1.79	0.11
	Computer Science	1.76	0.08	1.31	0.29	1.70	0.10

RQ1. Do the most popular searches developed by physicians, i.e., treatment, diagnosis, and learning on a specific medical topic, lead to different search performance between computer science students (with higher information search skills but lower medical knowledge) and medical students-residents (with higher medical knowledge but lower information search skills)?

Time spent to find information

Concerning the time required to find information, no significant differences appeared between students-residents in medicine and in computer science for any tasks (all *t* tests were non-significant) – see Table 2.

Keywords related to medicine added by the participants

Students-residents in medicine added more keywords related to medicine than students in computer science ($t(18)=-4.57$, $P<.001$, d=2.04) only for learning task: in mean 1.6 (SD=.91) for students-residents in medicine versus 0.3 (SD=0.48) for students in computer science. The keywords, added by students-residents in medicine, were mainly related to specific websites they knew (e.g. association of doctors in gynecology, government health agency websites) within they could find information on the topic.

For treatment and diagnostic tasks, statistical analyses did not show any significant difference between students-residents in medicine and in computer science ($t(18)=-1.32$, $P>.1$ and $t(18)=-1.16$, $P>.1$) – see Table 2.

Correct information found for diagnostic and treatment tasks and number of relevant information elements provided by participants for learning task:

For treatment and diagnostic tasks, students-residents in medicine provided more correct answers than students in computer science:

- For treatment task ($t(18)=-6.77$, $P<.001$, $d=-3.03$): in mean 0.85 (SD=0.15) for students-residents in medicine versus 0.1 (SD=0.31) for students in computer science.
- For diagnostic task ($t(18)=-9$, $P<.001$, $d=-4.02$): in mean 0.9 (SD=0.31) for students-residents in medicine versus 0 (SD=0) for students in computer science.

For learning task, even with the correction of the square root ($\sqrt{}^2$), the homogeneity of variance was violated. So, we applied non-parametric test (Mann-Whitney test). Students-residents in medicine

provided more relevant information elements than students in computer science (*U*(18)=30, *P*=.03, rank biserial correlation=.4), with in mean 3.9 (SD=.31) for students in medicine and 3.5 (SD=.52) for students in computer science – see Table 2).
As illustrated below with the four examples (see Table 3), the information elements provided for learning task by the participants differed with regard to their expertise. Indeed, this task was exploratory and was approached differently depending on the expertise of the participants. Students-residents in medicine generally developed in an exhaustive way specific to medicine: definition and prevalence, symptoms, causes and consequences, diagnosis, possible treatments. Whereas students in computer science focused mainly on definition-prevalence and symptoms; very few of them provided possible treatments. Their answers were more superficial than those of students-residents in medicine, who applied the medical schema to obtain information on the pathology.

Table 3. Examples of answers provided by students-residents in medicine and students in computer science with their description.

Students-residents in medicine	**Types of information provided**
Example 1: Symptoms and signs: Intense dysmenorrhea, Dyspareunia, Pain on fecal exoneration and catamenial urinary tract sign, Infertility Gynecological examination: bluish lesion on speculum examination, Appendages fixed on vaginal touch, Uterus inverted, Pain on mobilization of adnexa Risk factors: Early first menstrual period, Menorrhagia, Short cycles, - Onset in1st degree Management: clinical examination + endovaginal ultrasound first; If deep location, infertility, endometrioma or resistance to treatment → MRI or endovaginal echo; Diagnostic laparoscopy only if diagnosis uncertain; Infertility consultation if fertility issues; Systematic investigation of other locations Concerning medical treatment: No COP, progestin or GnRH analogue, whether combined with surgery or not. However, GnRH analogues should not be prescribed before the age of 18; In terms of analgesics, only NSAIDs are not recommended, as they are too iatrogenic. As far as infertility is concerned, the 2 points to remember in my opinion are: - Do not undertake excision of endometriosis sites for the sole purpose of improving IVF results, whatever the severity. - In cases of deep endometriosis, IVF can be an effective means of increasing the chances of successful conception.	Symptoms Causes and consequences Diagnostic Possible treatments
Example 2: - Histological diagnosis = presence of endometrial (uterine) tissue outside the uterus - Not necessarily progressive over time, according to current data - No systematic follow-up for asymptomatic patients on treatment - Cause of infertility + pain - 1st intention check-up (my mistake before): → Clinical examination, including gynecological examination → Echopelvic (or MRI if in doubt) → If diagnosis → always look for deep endometrioma - Then in2nd intention:	Diagnostic Prognostic Medical follow-up Consequences Diagnostic

→ Pelvic MRI → Endometrial ultrasound - Treatment (1) Hormonal: Estropro contraception, Hormonal (2) Non-medicated treatment: Acupuncture, osteopathy... Large topic, difficult to choose what to talk about...	Possible treatment
Students in Computer Science	**Types of information provided**
Example 3: One in ten women of childbearing age is affected by endometriosis, potentially all women in good health. Causes severe gynecological pain and damage to various organs. The endometrium is the tissue that develops and lines the uterus. Endometriosis is when it develops outside the uterus, such as in the fallopian tubes/ovaries.	Statistics Superficial consequences Superficial description/definition
Example 4: - A very common disease, not necessarily discovered because it can be asymptomatic. - Disease linked to the endometrium, where the cells outside the uterus remain sensitive to hormones. - This can lead to pain, infertility and cysts. Treatments are available: pain relief or ablation.	Superficial description Superficial consequences

RQ2. What resources and their level of credibility do they consult when they perform medical search tasks and with regard to their knowledge?

Credibility resources consulted: score and websites used:

Firstly, concerning the credibility scores obtained (DV4a), students-residents in medicine obtained higher scores than students in computer sciences for learning task: in mean 5.85 (SD=4.37) for students-residents in medicine versus 2.2 (SD=2) for students in computer science (t(18)=-2.40, P<.05, Cohen's d=1.08). For diagnostic task, only a marginal effect appeared (t(18)=-1.48, P=.07): in mean 13.45 (SD=9.63) for students-residents in medicine versus 8 (SD=6.53) for students in computer science.

For treatment task, no significant difference appeared between the two groups: in mean 6.9 (SD=4.67) for students-residents in medicine and 5.4 (SD=4.09) for students in computer science (t(18)=-0.76, P>.1).

Then, we analyzed the repartition of internet resources (websites) used (DV4b) (see Figure 1).

The resources had not the same place during information search (F(3,54)=28.12, P<.001, η^2_p=0.61): websites/documents from hospitals were more used than the other ones (Ps<.001).

We analyzed more precisely the use of each resource with regard to expertise domain and task; we observed:

- For evidence-based resources, no significant difference appeared between students-residents in medicine and students in computer science (F(1,18)=0.31, P>.5). These resources were very few visited by all participants.
- For hospital websites, students-residents in medicine used more them than students in computer science (F(1,18)=13.96, P<.001, η^2_p=0.44).
- For HONcode health websites, we observed that students in computer science consulted more

these resources than students-residents in medicine ($F(1,18)=6$, $P<.05$, $\eta^2_p=0.25$).

- For other websites, the students in computer science used more them than students-residents in medicine ($F(1,18)=5.21$, $P<.005$, $\eta^2_p=0.34$).

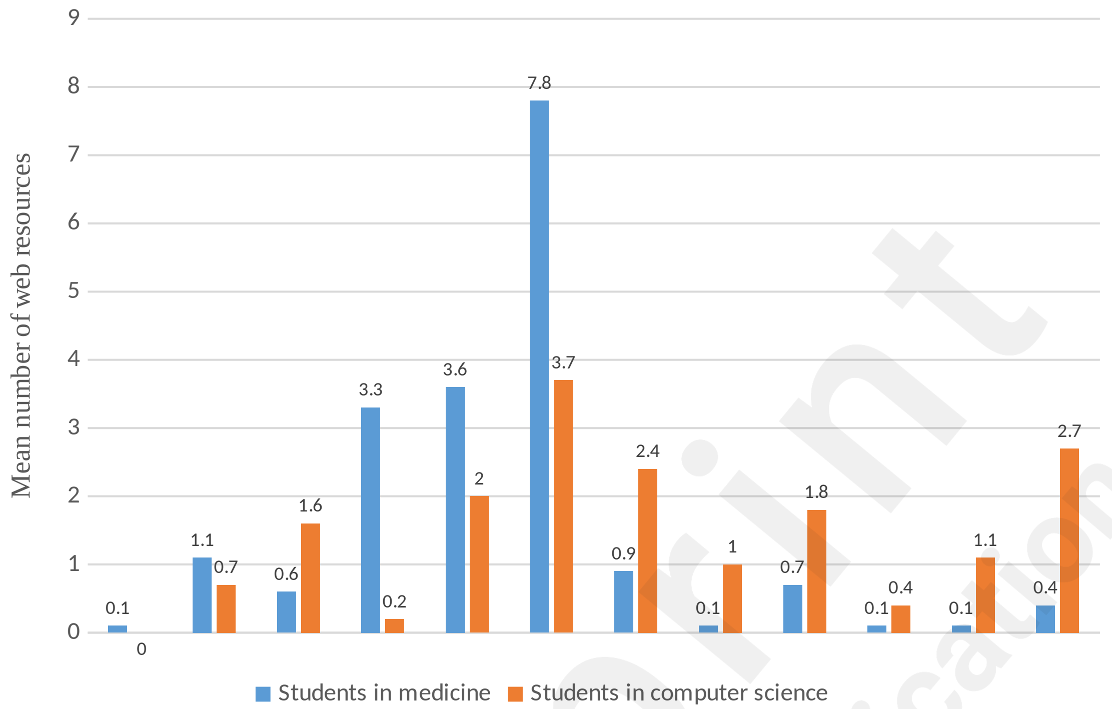

Figure1. Means (and standard deviations) of web resources consulted with regard to the expertise domain of students

Then, we examined at main websites used *via* URL opened up (see Table 4):

Table 4. Main websites visited by participants and their score with regard to the search task to be performed.

Learning tasks		**Authority versus Non-authority websites and scores obtained**
Students-residents in medicine	www.has-sante.fr (government health agency) www.cngof.fr (association of physicians in gynecology)	Authority; score = 1,5p Authority; score = 1,5p
Students in computer science	www.endofrance.org/ (association of patients with endometriosis) non-official health websites (e.g. www.passeportsante.net, www.pourquoidocteur.fr)	Non-authority; score = 1p (verified by HonCode) Non-authority; score = 0p
Diagnostic task		
Students-residents in medicine	www.campus.cerimes.fr (digital medical campus which was not updated since 2016) www.medecine.ups-tlse.fr/ (or other university hospital)	Authority; score = 1,5p Authority; score = 1,5p
Students in	www.e-sante.fr	Non-authority; score = 1p

computer science	www.journaldesfemmes.fr/ www.wikipedia	(verified by HonCode) For the last two URLs: Non-authority; score = 0p
Treatment task		
Students-residents in medicine	https://www.revmed.ch/ (Swiss medical journal) www.has-sante.fr (government health agency)	Authority; score = 2p Authority; score = 1,5p
Students in computer science	https://www.revmed.ch/ (Swiss medical journal) the other websites consulted are very different from one participant to another	Authority; score = 2p

RQ3. Do they assess differently the reliability of sources they choose to use and the quality of answers they provided for the search task to be performed?

Self-assessment of reliability of web documents consulted in answering to this question at the end of each session (7 points max):
Only a significant difference appeared between students-residents in medicine and CS for learning task ($t(18)=-3.13$, $P<.005$, d=-1.39): in mean 6.8 (SD=0.42) for students-residents in medicine versus 5.8 (SD=0.91) for students in CS. For treatment and diagnostic tasks, statistical analyses did not show any significant difference between students-residents in medicine and in computer science ($t(18)=-1.24$, $P>.1$ and $t(18)=-1$, $P>.1$) – see Table 2.

Self-assessment of quality of answers provided on 4 point-scale for the three tasks. Participants had to indicate his/her perception of answer quality ("I think the answer I provided is: very bad (1) to very good (4)):
For all search tasks, students-residents in medicine evaluated higher the quality of their answers:

- For learning task: in mean 3.5 (SD=0.52) for students-residents in medicine versus 3.1 (SD=0.31) for students in computer science ($t(18)=-2.05$, $P<.05$, d=-0.92).
- For diagnostic task: in mean 3.2 (SD=0.42) for students-residents in medicine versus 2.9 (SD=0.31) students in computer science ($t(18)=-1.8$, $P<.05$, d=-0.80).
- For treatment task: 2.9 (SD=0.31) for students-residents in medicine versus 1.8 (SD=0.78) students in computer science ($t(18)=-4.09$, $P<.001$, d=-1.83).

Discussion

Discussion of main results

This study aimed to determine the way medical students and residents search for medical information on the Internet, the resources they use (including the nature and level of credibility of these resources), and how they evaluate the reliability of these resources and the answers they provide. More precisely, the search behaviors of medical students-residents were compared to those of computer science students. Medical students-residents have higher medical-related knowledge, whereas computer science students possess higher procedural knowledge in information systems (i.e., better information search skills). Several prior studies have argued that the main issue for physicians when searching for information is their lack of information search skills [2,22]. To clearly test this theoretical hypothesis, this study aimed to determine if prior knowledge in medicine allowed medical students and residents to achieve higher search performance and make better choices regarding reliable resources than computer science students, who are experienced in information searching (i.e., possess higher information search skills).

Concerning performance in information searching, the results showed that medical students and residents performed better than computer science students: they provided more correct answers for treatment and diagnostic tasks, and more relevant and structured elements for learning tasks without requiring more time (see Table 3 for examples). Their background in medicine allowed them to achieve higher scores of correct answers, better evaluate the reliability of resources, and choose web resources more efficiently than computer science students. These results partially contradict previous works that indicated difficulties for medical students and physicians in finding information on the web due to a lack of information search skills.

Medical students-residents needed approximately 9 to 11 minutes to provide answers, which aligns with prior studies [2]. They also inferred more medical-related keywords to find information than computer science students, particularly when dealing with learning tasks. In reality, these keywords allowed them to consult known websites to obtain the required information. Therefore, their medical knowledge was effectively utilized, as they used relevant medical-related keywords with Google and could locate accurate information as quickly as computer science students, who were fast but not as efficient. These results about medical-related keywords generated by participants partially corroborate previous studies, which showed that the vocabulary used was more medically specific for experts in medicine than non-experts (e.g., [37,38,39]). Medical students-residents also assessed their answers as more reliable than computer science students. They had confidence in the information they found, reflecting their ability to find correct and reliable information on the internet and hospital websites, which corroborates previous works [2].

Concerning the objective score of credibility of web resources consulted and the reliability self-assessment of resources used by the participants, the results showed that medical students-residents used more credible websites than computer science students for learning tasks and close significance for diagnostic tasks (P = .07 for diagnostic). For treatment tasks, the scores between the two groups were similar (no significant difference). Learning and diagnostic tasks may require high medical-related knowledge to choose credible and reliable resources. Indeed, to make a correct diagnosis, physicians must eliminate all other possible pathologies (i.e., differential diagnosis), which requires ensuring that the symptoms correspond only to the diagnosed pathology. For this purpose, general-purpose websites are not adequate; medical students-residents had to use credible websites to consult previous cases, for instance. For learning tasks on a specific topic, physicians must visit up-to-date resources to ensure they obtain recent and reliable information, which also requires medical websites.

When analyzing the websites consulted more precisely, differences between medical students-residents compared to computer science students were noted with regard to the task to be performed. Firstly, evidence-based resources were seldom used by all participants and were mainly used for diagnostic and treatment tasks. This result may be surprising for medical students-residents since they were in training, but it may relate to observations that very few medical practitioners used PubMed and more generally evidence-based resources [40,41]. Physicians experience difficulties in formulating relevant keywords and may deal with many irrelevant articles while using PubMed [42]. Therefore, it is possible that physicians and medical students prefer using familiar websites to find medical-related information. In our experimental study, medical students-residents mainly used resources from hospitals for all tasks and more often than computer science students. These results corroborate those obtained by [18], showing that physicians consult familiar websites to reduce the time spent searching for information. Physicians go directly to preferred or trusted medical sites [43,44,45]. They used various criteria to judge the value of information, focusing on information quality (usefulness, goodness) and authority (trustworthiness, authority) [19]. These criteria may apply to hospital websites and documents. In addition, physicians tend to search for more methodical and empirically medical solutions to reduce the error risk in medical decisions while maximizing their medical effectiveness, as shown by [6]. In our study, computer science students used more HONcode health websites and other websites (not verified). Computer science students may experience difficulties in assessing the credibility of websites used and/or understanding information displayed on medicine-related websites such as PubMed and hospital websites.

Conclusion, implications and limitations

The main results show that medical students-residents generally found correct information, but they used very few evidence-based tools (e.g., PubMed). As shown by [42], it is possible that they do not use these databases because they may miss relevant articles while retrieving too many irrelevant articles. They have difficulties using the correct filters to find relevant articles. Therefore, future research should focus on helping physicians use these tools. Indeed, clinical and practical evidence-based medicine can contribute to updating physicians' knowledge, improving patient care, and positively affecting physician-patient relationships [46]. Indicative of this phenomenon is a study by the Institute for Healthcare Informatics published in January 2014, which ranks Wikipedia as the preferred source of healthcare information for doctors [47]. In our study, Wikipedia was very rarely used by participants in medicine.

Therefore, it could be relevant to integrate training for students and physicians to use these tools efficiently for their (future) practice, especially evidence-based tools. For example, we could introduce them to the contents of HONcode, explaining the different categories of websites, the types of medical information they provide, and how to identify reliable sources based on the URL domain (.org, .gov) versus unreliable or less reliable sources (.net).

Healthcare professionals at every stage of their careers must continue to learn about advances in research, treatments, knowledge, and skills required to provide safe and effective patient care. Online scientific databases are very relevant tools to support their activities, especially with the increasing use of generative AI as search engines, such as ChatGPT, which provides poorly sourced information compared to Google [48].

In addition to training programs for medical students and physicians, it would be beneficial if general search engines (such as Google) could identify queries related to medical research and provide verified resources (such as Google Scholar or PubMed) on the search engine result pages. General search engines could also support specialized medical queries by suggesting medical keywords related to the task at hand. At least students in medicine and physicians would be more familiar with the interface and would find the required information more quickly than with PubMed, which they find difficult to use efficiently.

The study presented in this article also has some limitations. It involves only a few participants, so it could be relevant to replicate this study with more participants, including medical students, residents, and both junior and senior physicians. Since physicians must continually update their knowledge throughout their professional careers, it would also be relevant to determine the search behavior of physicians at different stages of their profession (e.g., keywords formulated, websites visited, etc.).

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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