Abstract
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Purpose: To summarise research pertaining to the use of online resources by medical students throughout the course of their studies in a literature review.

Method: Twenty studies published between 2003-2017 were identified for inclusion in the review. All reviewed papers reported on medical students use of online resources for their studies, both in preclinical and clinical settings.

Results: Of the studies initially identified, twenty studies focusing on medical students were included and reviewed. The online resources, most frequently mentioned were UpToDate (35%); Epocrates (35%); Medscape (25%), Google (25%); PubMed (20%); Micromedex (20%); Wikipedia (15%); PEPID (10%); Dynamed (10%). Fourteen studies linked the use of online resources to their accessibility and reliability. In nine studies students reported that online resource use enhanced clinical management and diagnostic accuracy.

Conclusion: Research on the use of online resources by medical students is largely limited to their use in clinical settings. As technology and learning evolve there is an increased need for students to be able to access such resources online and have the required teaching to understand how best to utilise them.

Keywords
online resource, medical students
**Background**

In addition to lectures, textbooks and tutorials, medical students are increasingly accessing mobile technology and online resources for learning. There is evidence of widespread use of smartphones and iPads in clinical settings to find information (Peterson et al., 2004). The number of online resources available is growing exponentially, however, not all resources are equally useful for use by medical students (Khalifian et al., 2013). The purpose of this literature review is to identify what online resources are commonly used by medical students for learning and why they are used.

**Method**

We searched PubMed, Europe PMC, Wiley Online Library, ResearchGate amongst others to select relevant research studies for a literature review and summarised our findings. We decided on criteria that were particularly relevant to our literature review and searched for studies that focused on both medical students and their use of online resources. This search was conducted on the 16th March 2020. Twenty studies, published between 2003-2017 were identified, included and reviewed that reported on medical students’ use of online resources, both in preclinical and clinical settings.

**Inclusion and exclusion criteria**

We limited our search first to studies carried out from 2003 onwards. We then limited our search to academic journals written in English. As we refined our search, we excluded papers that focused on groups outside of medical students and those that failed to mention the use of electronic resources. We included papers with a focus on medical education. Studies included were not limited to online resource use for any particular learning task. Our definition of medical student didn’t include premedical students. In addition to this, our assessment of what an ‘online resource’ includes was open to any programmes, database or application used by the medical student for learning relevant to any health topic.

**Results**

Twenty studies, published between 2003-2017 were identified, included and reviewed. A quarter of studies looked at the use of online resources in both preclinical and clinical settings, while 60% looked only at clinical, and the remainder of studies did not specify.

**Participants**

Studies looked at the online resource use of medical students at various stages in their degree, with 10% focusing on 2nd year, 20% on 3rd year, and 15% on 4th year medical students. The remaining studies surveyed all medical students in a school, so it is unknown what percentage of their results pertain to which year group.

**Online resources**

A variety of online resources were mentioned across these papers, the most dominant being UpToDate (35%); Epocrates (35%); Medscape (25%); Google (25%); PubMed (20%); Micromedex (20%); Wikipedia (15%); PEPID (10%); Dynamed (10%). UpToDate, Epocrates and Medscape were perceived to be among the most trustworthy for preclinical and clinical students (Quant et al., 2016). One study examined what databases were used most by students, showing Ovid, New England Medical Journal and The British Medical Journal as the most popularly used (Lai and Nalliah, 2010). However, another study indicated that no student downloaded either Ovid or PubMed/Medline (Chatterley and Chojecki, 2010), suggesting that while used, databases are not the dominant resource used by students online. Three studies reported the use of Wikipedia as a commonly used resource (Twiss-Brooks et al., 2017) (Brennan et al., 2014) (Choi-Lundberg et al., 2016), one of which reported it as the most frequently accessed resource by students despite recognising that it should be approached with caution due to quality of content and reliability (Brennan et al., 2014).

**Use of resources**

Studies reported that online resources were used by medical students to access medical knowledge, to enhance clinical management information and diagnostic accuracy, to inform patient care, and to support test taking. Nine studies reported the reason medical students selected online resources as an educational tool was mainly due to their ease of access, convenience, reliability, alignment with curriculum and quality of information (Peterson et al., 2004) (Twiss-Brooks et al., 2017) (Khalifian et al., 2013) (Brennan et al., 2014) (Choi-Lundberg et al., 2016) (Garrett and Jackson, 2006) (Aparicio et al., 2012) (Baudains et al., 2013) (Lau and Kolli, 2017). Fourteen studies reported that medical students frequently used online resources in a clinical setting in order to access clinical management information and inform patient care (Peterson et al., 2004) (Boruff and Storie, 2014) (Twiss-Brooks et al., 2017) (Khalifian et al., 2013) (Quant et al., 2016) (Brennan et al., 2014) (Garrett and Jackson, 2006) (Aparicio et al., 2012) (Baudains et al., 2013) (Lau and Kolli, 2017) (Collier et al., 2007) (Graber, Tompkins and Holland, 2009) (Lasserre et al., 2010) (Klinski et al., 2011) (Nuss et al., 2014). A comparative study of four free online applications reported that Medscape had the highest satisfaction due to its user-friendly, interactive educational content; Epocrates and Micromedex were both considered excellent for information on drugs, but Epocrates was preferred more for its user-friendly, educational content; and
although Google was the most frequently used, it was limited in its clinical management information (Khalifian et al., 2013). One study showed a more personal use of the PDA as it was used for professional reflection, to get commentary, and assessment (Garrett and Jackson, 2006). Another study reported that only 4% of students used websites and only 5% used software as a preferred resource for the study of anatomy (Chatterley and Chojecki, 2010). A further study reported that students sometimes used inadequate internet resources which may not be objective or reliable, leaving much for medical education to address (Templeman, Robinson and McKenna, 2016).

**Effect of online resources on students**

Three studies looked at the effect of the use of online resources on students. One showed that the repeated use of online resources increased the students confidence in navigating different journals (Lai and Nalliah, 2010). Another demonstrated that the removal of a decision support tool from the student, shows no significant deterioration in the student’s improvements attained, suggesting that there is at least short term sustainability of the education effects of using online resources (Leung GM et al., 2003). The third study found that 90% thought medical apps enhance clinical knowledge and had a positive effect on their education (Quant et al., 2016).

**Accessibility of resources**

One study noted that 59.1% of 3rd and 4th year clinical students used mobile devices to access online information more than once a day, in comparison to only 26.8% of 1st and 2nd year students (Boruff and Storie, 2014). When it came to learning how to use such resources 75.4% were self-taught, 29.8% peer taught, and 10.5% were taught by the library staff. Students thus suggested instruction sessions may be helpful, with 41.9% suggesting small group interactive sessions, 40.3% an online tutorial, and 16.1% lecture style (Chatterley and Chojecki, 2010). Interestingly, one study reported that females significantly used more internet resources than male students did (86.9% versus 68.5%) (Baudains et al., 2013).

**Discussion**

In this literature review of twenty studies, evaluating the use of online resources by medical students, we found that papers focused on the use of electronic knowledge resources used by medical students in their preclinical and clinical years. The dominant resources used were Epocrates, Medscape, and UpToDate. Studies all shared focus on clinical skill development through online resources with few studies investigating usage of online resources as a learning aid for lectured subjects e.g. physiology. Only 15% of studies looked at incorporation of the use of online resources into curriculum, with students suggesting the use of online tutorials, small group learning, and lectures to instruct students how to best utilise such resources (Quant et al., 2016) (Lai and Nalliah, 2010) (Chatterley and Chojecki, 2010). Studies also examined factors such as cost of resources, effect of resources on student learning, and the sustainability of such effects. Another significant factor impacting the use of online resources by medical students is their reluctance to use such resources in front of patients due to fears of appearing less competent (Quant et al., 2016).

**Limitations**

This literature review focuses only on studies involving medical students and therefore does not represent the current use or needs of students of other health science disciplines. Knowledge resources are continually evolving, and as a result older studies may be less pertinent to today’s use of online resources. A more significant development within this timeframe is the introduction of smartphones to medical learning. Between 2003 and 2017 there was a 460% increase in internet usage as it became more readily accessible (Internetworldstats.com, 2020). During this time smartphones too became increasingly popular, allowing medical students access to an abundance of material much faster than before (Statista.com, 2020). Although many of the older studies focus on Personal Digital Assistant usage, their findings are still significant as it was found that there was no major shift in the general usage pattern of smartphones compared to their predecessor, the PDA. All studies examined the use and outcome of online resources in clinical and preclinical settings, failing to examine the use of such resources as a learning aid for non-clinical subjects e.g. biochemistry.

**Take Home Messages**

- As online resources become more accessible and abundant, it is critical that their use both in clinical settings, and as a learning aid are examined, as well as the effect of such aid on the student’s confidence, recall ability, and patient engagement.
- There may be a need for studies examining the usage patterns of medical students over the course of their years studying medicine.
- While most studies seem to analyse the use of scholarly resources, it may be beneficial to look at the use of all online resources used over the course of the medicine degree.
- There is scope too, to examine the use of such resources by other health science students, and the integration of the online resource use into curriculum teaching.

- Due to the recent outbreak of COVID-19 the need for students to carry out learning, lectures and examination from home has highlighted the necessity for further exploration of online resources and their use in medical learning.

Notes On Contributors
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Declarations
The author has declared that there are no conflicts of interest.

Ethics Statement
Not required as this is a review of the literature.

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Natia Jojua
European University

This review has been migrated. The reviewer awarded 4 stars out of 5

Very important topic especially during current pandemic situation. Critical questions and data are presented by authors, however I would like to read more deep analysis of the results and recommendations for the teachers and administration. Many questions are raised from the data given by the authors which can be addressed for the future studies. As it is mentioned in the article majority of the students (75.4%) were self-taught how to use online resources, 29.8% peer taught, and 10.5% were taught by the library staff. How to find relevant information and how to do the critical analysis of it is very important skill of the future doctor. How to navigate in the ocean of information available online must be taught by the teachers from the 1st year of medical education.

Competing Interests: No conflicts of interest were disclosed.

Reviewer Report 29 June 2020

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James Gray
University of Sheffield

This review has been migrated. The reviewer awarded 3 stars out of 5
A relevant topic which is hampered by the search strategy as noted by other reviewers. We have previously published work on this topic in MedEdPublish which is excluded from the search but is pertinent to this particular area of study. https://doi.org/10.15694/mep.2020.000012.1I would commend the authors for mentioning the focus on medical students as certainly there is a lack of literature for wider clinical professions and this is something that could be very usefully explored.

**Competing Interests:** No conflicts of interest were disclosed.

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**Viktor Riklefs**  
Karaganda Medical University

This review has been migrated. The reviewer awarded 3 stars out of 5

The topic is certainly relevant, especially taking into account the recent COVID-19 pandemic, where most of the schools were forced to online learning and most of the library resources became unavailable to students. However, as noted by previous reviewer, it is not quite clear what were the inclusion/exclusion criteria for literature into this review and why the most recent years (2018, 2019) were not included. Most certainly the article is also lacking the logical framework, explaining the reasons why certain resources are used or not used by students. Without the logical framework it is very hard to make the information useful for the readers, whether they are learners, teachers or administrators. For example, why do students prefer to use resources that lack reliability, such as Google or Wikipedia? Are there certain trends that could be considered universal and should be adapted by different medical schools? But rather than answering these questions, the article just gives the references to different views or different authors, without even making an attempt to bring some foundation to the topic, answer some specific research question or show the gap in the current knowledge. At the same time, the article gives a nice overview of some ideas regarding the use of online resources that are explored in the current literature. This could be used by other researchers to elaborate further on the topic or plan their own research. But it could be much more beneficial if certain recommendations were made to either learners, teachers or administrators to make learning experience in their medical schools better.

**Competing Interests:** No conflicts of interest were disclosed.

Reviewer Report 26 June 2020
This review has been migrated. The reviewer awarded 4 stars out of 5

The article examines the use of online resources by medical students over a period of fifteen years from 2003 to 2017. Is there any reason why the years 2018 and 2019 were not included? Their use of the term 'online resources' was very broad and referred to any program, database or application used by medical students for learning relevant to any health topic. As mentioned by the authors from 2003 there has been increasing use of smartphones and many apps have been developed. Wikipedia is a preferred resource by students and the quality of information on the site is improving. Cost may be an important factor influencing student use of a resource and Wikipedia is well-known as a free resource. It will be interesting to know the full list of indexing and abstracting services used by the authors to search for articles. During the last seventeen years some educational resources have become less popular while others have gained in popularity. The authors mention about the reluctance of students to use these devices in front of patients for fear of appearing less competent. In today's world information is readily available and the challenge is to critically appraise and make sense of the information. Looking things up as and when required may be a safer alternative to relying on human memory, which is often fallible. Patients should be educated to accept their health professionals looking up information as and when required. Medical and other health science students are learning to access information online as the article mentions and this should be encouraged. Their critical appraisal skills should be developed enabling them to access good quality resources online.

**Competing Interests:** No conflicts of interest were disclosed.