HeadToToe: A Mobile Medical Knowledge dissemination platform: strengths, limitations and preliminary usage assessment.

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Table of Contents

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Abstract

Background: Finding readily accessible high-quality medical references can be a challenging task. HeadToToe is a mobile platform designed to allow easy and quick access to sound, up-to-date, and validated medical knowledge and guidance. It provides easy access to essential clinical medical content in the form of documents, videos, clinical scores and other formats, for the day-to-day access and use by medical students and physicians during their pre- and post-graduate education.

Objective: The aim of this paper is to describe the architecture, user interface and potential strengths and limitations of an innovative knowledge dissemination platform developed in the University of Geneva, Switzerland. We also report preliminary results from user experience survey and usage statistics over a selected period.

Methods: The dissemination platform consists of a smartphone application. Through an administration interface, content is managed by senior University and Hospital staff. The application includes the following sections: (1) main section of medical guidance, organized by clinical field; (2) checklists for history-taking and clinical examination, organized by body systems; (3) laboratory section with frequently used lab values; (4) favorites section. Each content component is programmed to be available for a given duration as defined by the content's author. Automatic notifications signal the author when the content is about to expire, hence promoting its timely updating and reducing the risk of using obsolete content. In the background, a third-party statistical collecting tool records anonymous utilization statistics.

Results: We launched the final version of the platform in March 2019, both at the faculty of medicine and at the University Hospitals of Geneva in Switzerland. A total of 622 students in the University and 613 health professionals in the Hospital downloaded the application. Two thirds of users had an iOS device in both institutions. During practical examination period (May 2019) there was significant increase in number of active users ($p = 0.003$), user activity ($p = 0.0008$) and daily usage time ($p = 0.0004$) within medical students. In addition, there were 1,086 clinical skills videos views during this period compared to a total of 484 in preceding months (108% increase). On a ten-level Likert scale, students and physicians rated the app with mean scores of 8.3 for user experience, usefulness, and relevance of content. In parallel, postgraduate trainees viewed more than 6000 documents during the first 3 months after the implementation in the Division of Neurology in our institution.

Conclusions: HeadToToe is an educator driven, mobile dissemination platform, which provides rapid and user-friendly access to up-to-date medical content and guidance. The platform was given a high rate for user experience, usefulness and content quality and was used more often during exams period. This suggests that the platform could be used as tool for exams preparation.

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HeadToToe: A Mobile Medical Knowledge dissemination platform: strengths, limitations and preliminary usage assessment.

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Keywords: clinical skills; clinical competence; clinical practice guidelines; medical education; smartphone; innovation; medical guidance

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HeadToToe is an educator driven, mobile dissemination platform, which provides rapid and user-friendly access to up-to-date medical content and guidance. The platform was given a high rate for user experience, usefulness and content quality and was used more often during exams period. This suggests that the platform could be used as tool for exams preparation.

Introduction

The teaching of clinical skills (CS) and choice of management plans, are important cornerstones in medical schools' curriculum [1]. Skills like medical and personal history taking, physical examination and procedural skills are taught in parallel to more theoretical aspects and prepare the medical student for his clinical years. A medical student is expected to be able to examine patients displaying a large variety of complaints, as well as to perform many different medical procedures. Throughout medical school, student's CS are evaluated and in the Switzerland medical federal licensing examination, passing an Objective Structured Clinical Examination [2] test is mandatory in order to become a fully certified physician. Like any skill, CS improve with experience, repetition and constructive feedback provided by supervisors. Nevertheless, students rely on references (i.e. documents and videos) to prepare themselves for the clinical environment. [3, 4] Even though a multitude of references do exist for CS, the information is vast and scattered between a large number of sources and

finding high-quality and validated references can be a time-consuming and frustrating process [5, 6].

In the clinical environment, students and residents rely on clinical practice guidelines and recommendations to choose a treatment plan for a patient, which are, as mentioned, not always readily available [6]. Finding optimal guidance regarding clinical skills, procedural skills or patient management is challenging for all clinicians. It is even more so for students and postgraduate trainees, who seek not only sound and trustworthy guidance [7, 8], but also perhaps the most didactic, and one that fits the expectations of their educators and senior clinical staffs. Learners can thus benefit from a dissemination platform whose content is authored or endorsed by their local faculty, educators and senior hospital staff.

Moreover, the use of smartphones and other mobile devices in the medical environment, commonly termed as mHealth [9], has increased rapidly throughout the last years [10-12] and can offer not only patient-centered solutions for chronic illness management, behavioral change or self-monitoring [13-22] but also learning opportunities for pre- and post-graduate medical education [23]. The online environment plays an important role as well in continuous education, and health professionals rely on easy-access and high-quality medical content to improve patient care [24-27]. Furthermore, it was shown that health professionals favor significantly well-known targeted medical resources to more general web browsing in their search for what they perceive as validated medical content [28].

This increasing use of online resources and smartphones and need for easy-to-access validated and high-quality medical information urged the development of HeadToToe, a mobile platform intended for the dissemination of medical knowledge and tailored guidance for the pre- and post-graduate health professionals.

The purpose of the article is to describe the architecture of the tool, its potential strengths and limitations comparing to existing tools as well as to present preliminary evaluation of usage statistics and user experience. Our hypothesis, at this stage of development, is that users would perceive our platform as a rapid and user-friendly way to access up-to-date medical content and guidance, and that its content, being validated by local senior educators, would be therefore perceived as trustworthy and useful, both for education and practice.

Methods

Platform description

HeadToToe [29] platform consists of an iOS and Android Front-End compatible with iPhone, iPad, Android phones and tablets. Both Front-End connect to the same Back-End server which includes server-side code and a database allowing the centralization of all content and easy updating of the platform. The platform is managed through an administration interface (Figure 1), which is hosted on the same server as the database. A blank version (content-free) of the platform can be made available to other institutions for the purpose of academic collaborations.

Back-End (Database and administration interface)

Basic architecture

The server is hosted on Heroku and contains the database, the code and the Application Programming Interface (API) for its administration. API and administration interface is written with

Ruby on Rails. The administration interface provides a user-friendly interface for adding, deleting and editing content. The access to the administration interface is made through a weblink, restricted by a username and a password for *Educational Content Managers* (ECM), i.e. faculty educators and senior hospital staff managing content in HeadToToe.

Content Management

The cornerstone of the platform is that the ECM are responsible for identification, endorsement and updating of the content for the medical field under their responsibility. This provides the validation learners need to be able to trust that the content provided by the platform meet their education needs. The users themselves do not have access to the management interface and cannot upload their own content. Each time the application is launched or refreshed by the users, new or updated content is highlighted with a specific icon.

Content meta-data

Each content item has several attributes including title, subtitle, search keywords, link, thumbnail, update date and expiration date. An item can be a link to file, a video or a website. In addition, item's metadata include the full name and contact details of ECM, providing the users the possibility to communicate with content managers.

Content item responsibility

The content item responsibility can be defined by clinical field, sub-field or by individual content items. For example, the head of neurology could be the ECM for the whole neurology section or could delegate the responsibility for certain sub-fields or items to other senior medical staffs or educators.

Duration of validated content and updating mechanism

Medical knowledge and guidance, whether international, regional or local is always evolving. For each item, the ECM selects an expiration date thus defining the duration over which the content will be accessible users. Automatic notifications signal the author when the content is about to expire thus promoting its timely updating and reducing the risk of using obsolete content. Namely, 2 weeks and 24 hours before a content item reaches its expiration date an automatic email will be sent to the ECM to remind him about the expiration of the specific content. The ECM will then be able to decide if the item is still valid thus prolonging its availability on the platform. If the item is considered not valid, ECM may update it with a newer version or delete it. Eventually, expired items will be deleted automatically after a pre-defined period if no action confirms the validity of the resource.

Frontend (User interface)

The frontend of the iOS and Android application includes several sections:

The knowledge base

The knowledge base is the heart of the application (Figure 2.) containing the medical content and guidance organized by clinical specialty with folder hierarchy defined through the administration interface by the ECM of each section. Folder hierarchy is flexible and can differ between clinical fields. This section allows the user to navigate through each medical field's sections and find the needed content. After navigating to the desired section, the user can access files or media (videos or website links). An info button is available for each documents and media. A click on the button will open a popup view containing the item's meta data; contact details for the ECM, last update date and expiration date which would show in green as long as duration of its availability and in red when it is expired, it will stay red until it is either updated, manually deleted by the ECM or automatically deleted after a predefined period. For documents, a download button is present and allows download and offline use.

Admission

In this section (Figure 3.), users can find an extensive checklist with questions to be asked during history taking of a patient and actions to perform during clinical examination. Items can be checked, comments can be added to each item, and the user can generate a PDF containing checked items and comments.

Laboratory values (Figure 4.)

This section contains local reference values for frequently used laboratory values like complete blood count, chemistry, basic metabolic panel, arterial blood gas and more.

Favorites

Documents in the knowledge base can be marked as favorites. This section shows the list of favorites and allows to unmark them. Favorites are also found on the side menu of the application.

Search screen

The search screen (Figure 5.) is accessible throughout the app and allows a transversal search through all content (documents, media, lab values) for quick access to needed content. Search is made by item's title, subtitle and keywords defined in the administration interface to improve search accuracy.

Implementation and dissemination of the application in the institution

Target users of the platform are medical students in the Faculty of Medicine in the University of Geneva and post-graduate residents from University hospital of Geneva, Switzerland. The application is currently available for download exclusively through a private website in order to preserve content's copy and authors rights of local protocols as well as content imported from external sources. The iOS application is distributed through Apple's Enterprise distribution methods. Android app is distributed through the same website with an apk file. Students and physicians have separate versions for distinct statistical analysis. A student does not have the credentials to download the physicians' version and vice-versa to ensure statistical separation.

In the pre-graduate level, the application was implemented at the University of Geneva in 2015 as a beta version and the final version was released in March 2019. The medical curriculum consists of a fully integrated Bachelor, Masters, and Medical Degree six years program. The teaching of clinical skills starts from as early as the second year onwards and is taught in parallel and with relation to basic sciences studies until the end of the sixth year [30]. Therefore, the target public was medical students from the second to the sixth year of medical school, which are roughly 750 students at a given time. Since the launch of the final version of the application in March 2019, to date, the application was downloaded 622 times (counting multiple user devices).

At the post-graduate level, we first performed a pilot period from November 2018 to February 2019 and disseminated the application primarily in Division of Neurology at the University Hospital of Geneva, Switzerland. In March 2019, we launched the final version of the application and made it progressively available to the Divisions of General Pediatrics, Pediatric emergency, Neonatology, Neurosurgery, Pre-Hospital emergency care, Anesthesiology, Urology, Nephrology, Hematology, Diabetology, and Primary care. Our roadmap includes the implementation of HeadToToe in more divisions, and eventually the whole institution, in coordination with all relevant medical leadership. So far, the application was downloaded 613 times by doctors from mentioned divisions from a total of approximately 1900 doctors in our institution. (Table 1.)

Table 1. Users distribution between University students and hospital medical personnel since launch of the final version on March 2019.

	N (Downloads)	POTENTIAL USERS	POTENTIAL YEARLY RENEWAL
University of Geneva Students			
Total	622	750	150*
Apple Devices	430		
Android Devices	192		
University Hospital of Geneva Health Professionals			
Total	613	1900	300*
Apple Devices	409		
Android Devices	204		

N represents number of application downloads including multiple device download by the same user. Potential users represent an estimated number of target audience in mentioned institutions. * Potential yearly renewal is an estimate of new institutional students or employees and is based on mean number of new medical students per year as well as mean number of new medical staff in our institution.

Educational content managers, authoring or endorsing content

To ensure validated and high-quality content to the best of our possibility, we contacted senior physicians in different medical fields in our institution. Pre-graduate content was chosen by head faculty members responsible for clinical skills teaching and post-graduate content was selected by either head of divisions, units or other physicians from the respective division or units to whom the mission was delegated. Each of these specialists was responsible and contributed to his field's part in the platform with international and local content which he deemed updated, validated and useful for his fellow colleagues. Each department, division and unit in the institution can have its own section in the application without any content type or size restriction. The goal of combining pre- and post-graduate content was to allow a continuous usage of the platform from the student level, through residency and the rest of medical training.

Platform Development Process

Platform's concept emerged from an urging need and difficulties mentioned above of some of the authors to find high-quality and locally validated information concerning clinical skills during their medical university years. Several members of our team have dual training in computer science and medicine, which puts them in a position to be both code and architecture developers as well as end-users of the platform. This position made the design of the application and its architecture user-centered from its basic core as we were not only developing a product but a tool, we ourselves use in our daily practice.

To ensure an even more user-centered development process, before launching the final version, we have made several trial periods for pre- and post-graduate users in order try and understand each group's specific needs and to receive feedback. In addition to the post-graduate trail period described earlier, a beta version was launched in 2015 and used by 93 fifth year medical students in the University of Geneva before distributing the application to the rest of the faculty. In addition, both users and ECM have the possibility to send us feedback and ideas directly from the application and from the administration interface. Automatic utilization statistics allow us to identify most used type of content and thus to add similar content as well as to eliminate un-used content. At last, as discussed further in the paper, satisfaction surveys were sent to platform users with the possibility to write free-form text feedback.

These measures allowed us to improve user-experience, fix bugs and add requested features and content as were suggested by medical students and health professionals during each step of the development.

Platform Assessment

Evaluation of the platform utilization and usage was made in two different ways. First a factual analysis was conducted with data obtained from statistical collection by “Yahoo Flurry Analytics” to allow quantitative analysis of the utilization of the tool. Four different Flurry API keys were created to distinguish between iOS and Android apps and between Medical Students and Physicians. Collection was made continuously, anonymously and automatically. _

Events sent to Flurry by the iOS and *Android* applications are the title of the item, the medical field it belongs to, whether it was accessed by search or directly through the main knowledge base. Statistics are separate for medical students and doctors. This allows us to record summary statistics about how many times each item was used. Flurry collects automatically information about the usage of the application as the number of active devices per day, number of sessions per day, number of sessions per device per day, time of usage per device per day, median session length and more. The user’s journeys are also recorded, which means we are able to follow each user’s session and actions made in order the find needed information as well as the amount of time spent to retrieve it.

A second assessment focused on user satisfaction and qualitative utility was conducted through a survey. One survey was addressed to all medical students (from 2nd to 6th year of medical school) and another one was addressed to hospital physicians and nurses from the Division of Neurology as they were the first to use the application during a trail run. The surveys focused on user experience, general usefulness of the application and the relevance of the content (see Appendix 1 for survey questions). Surveys sent to both students and physicians were identical.

Statistical Analysis

p Values where calculated using unpaired t-test for continuous quantitative variable. Calculations where made using STATA© statistical software. $p < 0.05$ was considered significative.

Results

User demographics

As automatic statistics collection was anonymous, we do not have exact demographic knowledge regarding age and sex of users. We can estimate that mean age for University medical students is between 20 – 30 years and for medical doctors between 25 – 65 years. All users live in Geneva, Switzerland or its surroundings and are either medical students in the University of Geneva or Health professionals (Doctors or Nurses) in the University Hospital of Geneva. Distribution of downloads between the university and the hospital as well as between iOS and Android devices is summarized in Table 1.

Pregraduate analysis

Assessment of utilization

In the pre-graduate level, during the period from March to June 2019 a total of 251 students downloaded the application (iOS and Android combined). There was a significant raise in daily users and usage time with 16.5 *(SE = 1.9)* students per day from March to April 2019 compared to 24.5 *(SE = 1.8)* during exams period (*p = 0.003*, *Table 2a.)* for an average of 5.1 *(SE = 0.53)* minutes per day compared to 8.2 (*SE = 0.83*) during exams period (*p = 0.0008,* Table 2a.) and almost double the total number of sessions during exam period as compared to the months before (Figure 6.). Number of sessions per day increased significantly as well with 56.7 *(SE = 5.4)* sessions per day comparing to 89.5 *(SE = 8.3)* sessions during exams period (*p = 0.0004,* Table 2a.). The median session length, which may reflect the time each user needs to find the requested content, was 35 seconds. This fact can be cross-referenced with “user-journeys” gathered by Yahoo Flurry for each user’s session, which shows the exact navigation path each user made through the application and time spent. During this period 3,756 documents and 1,505 videos were consulted (Table 2b.).

Assessment of utility

In the pre graduate level, 138 students answered the survey. Students rated the app with a score of 8.2/10 *(SD = 1.88)* for user experience, 8.1/10 *(SD = 1.97)* for usefulness and 8.5/10 *(SD = 1.78)* for the relevance of content (Table 4.). 40% of students considered the videos section as the most useful and 43% considered the documents section as the most useful. 50% of students said they would like to see more procedural skills videos and 32% said they would like to see more clinical scores.

Table 2. Pre-graduate assessment of utilization during the months of March and April 2019 with comparison to exams period (May 2019) within 251 application downloads among medical students in the University of Geneva, Switzerland.

	EXAM PERIOD Mean (SE)	**CONTROL PERIOD** Mean (SE)	**MEAN DIFFERENCE** Mean (SE)	**p VALUE***
(a) DAILY ACTIVITY				
Active devices	24.5 (1.8)	16.5 (1.9)	+8.0 (2.8)	0.003
Minutes per user per day	8.26 (0.83)	5.16 (0.53)	+3.1 (0.95)	0.0008
Total Sessions per day	89.5 (8.3)	56.7 (5.4)	+32.8 (9.5)	0.0004
(b) CONTENT USE				
Documents consulted	1451	1252	+199	-
Videos consulted	1086	523	+563	-

Data from automatic statistics collection with Yahoo Flurry. SE = Standard Error. Exams period is defined as May 2019. Control period is defined as March and April 2019. *p-value calculated with unpaired t-test for continuous quantitative variable.

Postgraduate analysis

Assessment of utilization

At the post-graduate level, the application was downloaded 98 times (counting multiple devices per health-professional) during the trial period of three months, i.e., between November 2018 and February 2019. There was an average usage of 10.1 *(SD = 5.07)* users per day for an average of 8.1 *(SD = 8.56)* minutes per user per day with a mean of 55 *(SD = 35.45)* sessions per day (Table 3a.). Median session length was 29 seconds. During this period 6,494 files and 144 videos were consulted (Table 3b.). Documents viewed were mainly local guidance for acute stroke management.

Assessment of utility

Twenty-eight health-professionals answered the survey (Table 4.). User-friendliness was rated with a mean score of 7.8/10 *(SD = 2.24),* usefulness 8.6/10 *(SD = 1.73),* content relevance 8.5/10 *(SD = 1.49).* When asked for the most useful section of the application, documents were elected at 100%, compared to admission, videos and laboratory values. When asked for further content addition, 64% wanted to have additional protocols, 28% asked for clinical scores and 9% elected additional clinical skills videos as the most useful.

Table 3. Post-graduate assessment of utilization during a trail period within health professionals in the Neurology division in the University Hospital of Geneva.

(a) DAILY ACTIVITY	**MEAN ± SD**	**RANGE**
Active devices per day	10.1 ± 5.07	2 - 26
Minutes per user per day	8.1 ± 8.56	0.8 - 66
Total Sessions Per Day	55.0 ± 35.45	6 - 162
(b) CONTENT USAGE	**N (TOTAL)**	**MEAN PER MONTH**
Documents Viewed	6,494	2134.66
Videos Viewed	144	48

Data from automatic statistics collection with Yahoo Flurry between November 2018 and February 2019. SD = Standard Deviation. RANGE represents MIN and MAX values for reported parameters.

Table 4. Pre and post-graduate assessment of utility

INSTITUTION	**N**	**USER EXPERIENCE MEAN ± SD**	**USEFULNESS MEAN ± SD**	**RELEVANCE OF CONTENT MEAN ± SD**
University of Geneva Medical Students	138	8.2 ± 1.88	8.1 ± 1.97	8.5 ± 1.78
Neurology Division, University Hospital of Geneva	28	7.8 ± 2.24	8.6 ± 1.73	8.5 ± 1.49

Values represent weighted mean score for a ten-level Likert scale survey answered by medical students in the University of Geneva and by physicians from the Neurology division in the University hospital of Geneva, Switzerland.

Discussion

Finding easy-access, high quality and validated evidence based medical content is a challenging task. The use of the online and mobile environment is increasingly growing and becoming a relevant tool for pre- and post-graduate medical education and clinical practice. Health professionals tend to favor the use of targeted medical online and mobile resources as compared to non-specific web browsing. In order to address these difficulties and to adapt to modern medical content consuming habits we have developed HeadToToe.

Medical students and Doctors using the application found our platform user friendly, generally useful, and perceived the content as practical and relevant for daily clinical practice. For example, during a pilot implementation phase in the Division of Neurology, 6500 documents where consulted in 3 months (about 72 per day).

Continuous and automatic user-based statistics, as gathered in our platform, can provide understanding of the students' learning process and helps identifying the most frequently used content items. During an evaluation period of three months since the distribution of the final version through March 2019 and June 2019, as well as statistics collection from the beta version since 2015, we noted daily constant use of the application with increased activity during exam periods with the same activity patterns for the last four years (Figure 6). Usage in 2017 is not shown as no statistics were gathered do to further development of the platform. We noticed progressive increase in use during the month preceding the exams period and were able to identify frequently used content during this period. These findings can allow future focus on students' needs and studying habits as frequently used content can be further developed. These findings might suggest as well that the platform may be used as a tool for exam preparation, specifically in the clinical skills field.

Numerous online and mobile platforms exist and provide highly validated and high-quality medical information. Geeky Medics [31] and Bates Guide to clinical examination and History taking [32] are examples of highly used and validated online and mobile platforms which provides access to clinical skills material. MDCalc website and app is an example of a useful tool for clinical scores calculation [33]. UpToDate and PubMed are other tools used for retrieving evidence-based medical knowledge and treatment plans [34]. These sources are just a few among others and their use and trustworthiness is widely recognized. Each of these tools provides quality information about a specific aspect of medical knowledge and they are complementary with regards to a specific clinical question [35].

However, local institutions often lack dissemination for clinically relevant content, endorsed by local medical educators. Different file managers, such as DropBox and Google Drive can be used [36, 37] but have obvious limitations. For example, they lack specific medical relevant structure and user experience and do not provide specific solutions for obsolete content management.

In contrast, our platform has several potential strengths. HeadToToe provides an easy solution for the dissemination of selected medical references within an institution. Content selection is educator driven which means that ECM from each medical field in a given institution can be responsible for content management and endorsement thus ensuring content validation and quality. Information can be retrieved from several validated knowledge bases and is not restricted to a single source. Users can then easily access information from a variety of medical fields through a mobile application and frequently used content can be tagged and downloaded for offline use. Through the administration interface, adding and updating content is simple and users will only have access to the most recent version of an item and are automatically notified of the arrival of the new content. Moreover, HeadToToe contains a programmatically expiration date for each item which ensures up-to-date content by automatically notifying the ECM when content is about to expire and requires new validation or updating of the item. When no action is taken, expired items will be automatically deleted. This is particularly important in the medical environment where evidence is evolving constantly and provides a continuously updated platform avoiding the dissemination of obsolete medical content. This feature would be harder to achieve with a simple file manager as obsolete content is difficult to identify, manage, and suppress and would require a manual updating system. Furthermore, the platform provides metadata for each item displaying information and contact details of the ECM as well as visibility of the updated and expiration date.

The centralization of institutional information within a single tool may help the integration of new medical staff at any stage of their medical career by providing quick and easy access to local practice guidance and practical information as important phone numbers, call schedule and more. For example, we observed that including both pre- and post-graduate material seems to facilitate implementation of the platform, as medical students are exposed to the platform early in their curriculum and continue to use it during clinical rounds and after graduation. This can help them transfer and apply knowledge and skills in the clinical environment and promote continuous education.

From an educational and academic point of view, the tool provides automatic monitoring of content usage and user activity and can provide information to ECM about content relevance and learners needs. Usage data gathered may provide interesting insights for research in the field of medical education. Another advantage of

the platform unified architecture is that is also offers a simple way to disseminate local medical knowledge to other academic or private partners. Indeed, we are developing targeted versions of the application, which can be customized for specific medical content intended for external use.

Data collected using the platform could help presenting more evidence for the utility of mHealth solutions in clinical practice. In fact, while many mobile solutions targeted for health professionals are being used on a daily basis, evidence is still lacking concerning their impact on clinicians' adherence to validated guidance and on the clinical impact on reducing unwarranted variation in practice. By monitoring user activity and content usage patterns, and linking it with clinical indicators, we might be able to present more concrete real-world data supporting the use of mobile platforms in clinical settings.

The platform might present as well a cost-effective and ecological solution [38, 39] for knowledge dissemination as it may obsolete the need for printing medical and practical information for new and current staff members, even more so for information that is updated frequently. In addition, platforms' use might present as time-efficient, and thus cost-saving for health professionals as knowledge is centralized and rapidly accessible within a mobile application thus saving the need to find an available computer and for web-browsing. The economic and ecological impact of this type of intervention was not yet studied and would be of better value when the platform is fully deployed within the institution.

The platform presents several limitations. First and main limitation is that it requires the validation and triage of a large amount of medical content as well as the coordination between several educators and requires content quality check, which could become time consuming, as more content accumulates on the platform. The designation of an ECM is a crucial part of the process and does require an active participation in the creation of the platform. Nevertheless, institutions are often required to locally adapt or endorse the use of international guidance and to translate it into local practice due to differences in populations and local resources. Thus, triage and centralization of medical content can be useful for identifying existing content and promoting it as well as identifying fields where content and evidence is lacking and need to be addressed in a given institution. Our experience and the uptake in our institution has so far been very positive but remains to be further assessed. Implementation and evaluation would also need to be assessed in other clinical environments and institutions.

To date, we did not include patients in our platform development and design process as they were not the target users of the mobile application. Nevertheless, as there is growing evidence for the importance of patients' input in mHealth interventions, especially for patient-centered resources [19, 40-42], inclusion of patients in future developments could be of interest specifically concerning their perception of the utilization of mobile devices by health professionals in daily practice.

The quality of the content can also be criticized as subjective and be a matter of debate. We indeed do not offer a technological solution for the measurement of content's quality. However, ECM, as mentioned, are senior medical staff and specialists who are by definition responsible for local strategies, medical education and treatment plans. Thus, content quality and relevance are guaranteed by the ECM's institutional role. Moreover, the application has the merit of making validated content transparent to all partners, and thus helps identify either information needs or conflicting guidance on similar topics. Institutions and local ECM would still need to use sound methods for critical appraisal of content to include. For content that amounts to recommendations for clinical practice, ECM should use trustworthiness criteria, such as the ones published by the Institute of Medicine [8, 43], or by leading experts like the GRADE working group [44].

Finally, all online content needs to meet copyright regulations, both for published content, as for locally created content.

Conclusion

HeadToToe allows medical educators to create a validated, high-quality and up-to-date reference platform for a simplified pre- and post-graduate medical education knowledge dissemination to the benefit of their students and medical staff. It is built for an easy and quick access. Users found the application user-friendly, relevant and useful for clinical practice. Implementation in different Universities and clinical settings would be the next natural step for assessing its relevance in broader settings and scalability. Utilization patterns should be

further examined in light of student's and residents' information needs and learning habits, both as a tool for exam preparation, and for daily clinical activity. The potential impact on the reduction of unwarranted variations in practice, quality of care, and economic outcomes, should be further studied and randomized trials could compare the use of such integrated dissemination platform to current available tools.

References

1. Elder A. Clinical Skills Assessment in the Twenty-First Century. Med Clin North Am. 2018 May;102(3):545-58. PMID: 29650075. doi: 10.1016/j.mcna.2017.12.014.
2. Zayyan M. Objective structured clinical examination: the assessment of choice. Oman Med J. 2011 Jul;26(4):219-22. PMID: 22043423. doi: 10.5001/omj.2011.55.
3. Kim JY, Myung SJ. Could clinical experience during clerkship enhance students' clinical performance? BMC Med Educ. 2014 Oct;14:209. PMID: 25273978. doi: 10.1186/1472-6920-14-209.
4. Vogel D, Harendza S. Basic practical skills teaching and learning in undergraduate medical education - a review on methodological evidence. GMS J Med Educ. 2016;33(4):Doc64. PMID: 27579364. doi: 10.3205/zma001063.
5. Thiele RH, Poiro NC, Scalzo DC, Nemergut EC. Speed, accuracy, and confidence in Google, Ovid, PubMed, and UpToDate: results of a randomised trial. Postgrad Med J. 2010 Aug;86(1018):459-65. PMID: 20709767. doi: 10.1136/pgmj.2010.098053.
6. Kritz M, Gschwandtner M, Stefanov V, Hanbury A, Samwald M. Utilization and perceived problems of online medical resources and search tools among different groups of European physicians. Journal of Medical Internet Research. 2013 Jun 26, 2013;15(6):e122. doi: 10.2196/jmir.2436.
7. Guidelines IoMUCoSfDTCP. Clinical Practice Guidelines We Can Trust. 2011.
8. Vandvik PO, Brandt L, Alonso-Coello P, Treweek S, Akl EA, Kristiansen A, et al. Creating clinical practice guidelines we can trust, use, and share: a new era is imminent. Chest. 2013

Aug;144(2):381-9. PMID: 23918106. doi: 10.1378/chest.13-0746.
9. Bradway M, Carrion C, Vallespin B, Saadatfard O, Puigdomènech E, Espallargues M, et al. mHealth Assessment: Conceptualization of a Global Framework. JMIR Mhealth Uhealth2017.
10. Gavali MY, Khismatrao DS, Gavali YV, Patil KB. Smartphone, the New Learning Aid amongst Medical Students. J Clin Diagn Res. 2017 May;11(5):JC05-JC8. PMID: 28658804. doi: 10.7860/JCDR/2017/20948.9826.
11. Morris CG, Church L, Vincent C, Rao A. PDA usage and training: targeting curriculum for residents and faculty. Fam Med. 2007 Jun;39(6):419-24. PMID: 17549651.
12. Gagnon M-P, Faculty of Nursing UL, Quebec City, Canada, Public Health and Practice-Changing Research CdQRC, Quebec City, Canada, Ngangue P, Faculty of Nursing UL, Quebec City, Canada, Public Health and Practice-Changing Research CdQRC, Quebec City, Canada, et al. m-Health adoption by healthcare professionals: a systematic review. Journal of the American Medical Informatics Association. 2020;23(1):212-20. doi: 10.1093/jamia/ocv052.
13. Ramsey WA, Heidelberg RE, Gilbert AM, Heneghan MB, Badawy SM, Alberts NM. eHealth and mHealth interventions in pediatric cancer: A systematic review of interventions across the cancer continuum. Psychooncology. 2020 Jan;29(1):17-37. PMID: 31692183. doi: 10.1002/pon.5280.
14. Payne HE, Lister C, West JH, Bernhardt JM. Behavioral functionality of mobile apps in health interventions: a systematic review of the literature. JMIR Mhealth Uhealth. 2015 Feb 26;3(1):e20. PMID: 25803705. doi: 10.2196/mhealth.3335.
15. Badawy SM, Barrera L, Sinno MG, Kaviany S, O'Dwyer LC, Kuhns LM. Text Messaging and Mobile Phone Apps as Interventions to Improve Adherence in Adolescents With Chronic Health Conditions: A Systematic Review. JMIR Mhealth Uhealth. 2017 May 15;5(5):e66. PMID: 28506955. doi: 10.2196/mhealth.7798.
16. Thakkar J, Kurup R, Laba TL, Santo K, Thiagalingam A, Rodgers A, et al. Mobile Telephone Text Messaging for Medication Adherence in Chronic Disease: A Meta-analysis. JAMA Intern Med. 2016 Mar;176(3):340-9. PMID: 26831740. doi: 10.1001/jamainternmed.2015.7667.
17. Majeed-Ariss R, Baildam E, Campbell M, Chieng A, Fallon D, Hall A, et al. Apps and Adolescents: A Systematic Review of Adolescents' Use of Mobile Phone and Tablet Apps That Support Personal Management of Their Chronic or Long-Term Physical Conditions. J Med Internet Res. 2015 Dec 23;17(12):e287. PMID: 26701961. doi: 10.2196/jmir.5043.
18. Zhao J, Freeman B, Li M. Can Mobile Phone Apps Influence People's Health Behavior Change? An Evidence Review. J Med Internet Res. 2016 Oct 31;18(11):e287. PMID: 27806926. doi: 10.2196/jmir.5692.
19. Badawy SM, Thompson AA, Liem RI. Technology Access and Smartphone App Preferences for Medication Adherence in Adolescents and Young Adults With Sickle Cell Disease. Pediatr Blood Cancer. 2016 May;63(5):848-52. PMID: 26844685. doi: 10.1002/pbc.25905.
20. Badawy SM, Cronin RM, Hankins J, Crosby L, DeBaun M, Thompson AA, et al. Patient-Centered eHealth Interventions for Children, Adolescents, and Adults With Sickle Cell Disease: Systematic Review. J Med Internet Res. 2018 Jul 19;20(7):e10940. PMID: 30026178. doi: 10.2196/10940.
21. Osborn J, Ajakaiye A, Cooksley T, Subbe CP. Do mHealth applications improve clinical outcomes of patients with cancer? A critical appraisal of the peer-reviewed literature. Supportive Care in Cancer. 2019 2019-07-04;28(3):1469-79. doi: doi:10.1007/s00520-019-04945-4.
22. P P, I Z, G B, N J, J Z, R H, et al. EMOTEO: A Smartphone Application for Monitoring and Reducing Aversive Tension in Borderline Personality Disorder Patients, a Pilot Study. Perspectives in psychiatric care. 2017 Oct 2017;53(4). PMID: 27439663. doi: 10.1111/ppc.12178.
23. Davies BS, Rafique J, Vincent TR, Fairclough J, Packer MH, Vincent R, et al. Mobile Medical

Education (MoMEd) - how mobile information resources contribute to learning for undergraduate clinical students - a mixed methods study. BMC Med Educ. 2012 Jan;12:1. PMID: 22240206. doi: 10.1186/1472-6920-12-1.
24. McCord G, Smucker WD, Selius BA, Hannan S, Davidson E, Schrop SL, et al. Answering questions at the point of care: do residents practice EBM or manage information sources? Acad Med. 2007 Mar;82(3):298-303. PMID: 17327723. doi: 10.1097/ACM.0b013e3180307fed [doi] 00001888-200703000-00016 [pii].
25. Casebeer L, Bennett N, Kristofco R, Carillo A, Centor R. Physician Internet medical information seeking and on-line continuing education use patterns. The Journal of Continuing Education in the Health Professions. 2002 2002;22(1):33-42. doi: 10.1002/chp.1340220105.
26. Foster CC, Macy ML, Simon NJ, Stephen R, Lehnig K, Bohling K, et al. Emergency Care Connect: Extending Pediatric Emergency Care Expertise to General Emergency Departments through Telemedicine. Acad Pediatr. 2020 Feb 26. PMID: 32112864. doi: 10.1016/j.acap.2020.02.028.
27. Dumestre DO, Fraulin F. Avoiding Breach of Patient Confidentiality: Trial of a Smartphone Application That Enables Secure Clinical Photography and Communication. Plast Surg (Oakv). 2020 Feb;28(1):12-8. PMID: 32110641. doi: 10.1177/2292550319880910.
28. De Leo G, LeRouge C, Ceriani C, Niederman F. Websites most frequently used by physician for gathering medical information. AMIA Annu Symp Proc. 2006:902. PMID: 17238521.
29. Windisch O, Zamberg I, Iselin C, Schiffer E. [Head To Toe, a medical knowledge distribution platform : a practical example in urology]. Rev Med Suisse. 2019 Nov 27;15(673):2205-8. PMID: 31778051.
30. Vu NV, Bader CR, Vassalli JD. [The current curriculum in medicine at the University of Geneva]. Rev Med Suisse Romande. 1997 Jan;117(1):65-8. PMID: 9082540.
31. Frere M, Tepper J, Fischer M, Kennedy K, Kropmans T. Measuring situation awareness in medical education objective structured clinical examination guides. Educ Health (Abingdon). 2017 2017 Sep-Dec;30(3):193-7. PMID: 29786019. doi: 10.4103/efh.EfH_306_16.
32. Young ER. Bates Guide to Physical Examination and History Taking, Seventh Edition. Anesthesia Progress. 2001 Spring;48(2):72-3.
33. Elovic A, Pourmand A. MDCalc Medical Calculator App Review. J Digit Imaging. 2019 Oct;32(5):682-4. PMID: 31025219. doi: 10.1007/s10278-019-00218-y.
34. Hoogendam A, Stalenhoef AF, Robbe PF, Overbeke AJ. Answers to questions posed during daily patient care are more likely to be answered by UpToDate than PubMed. J Med Internet Res. 2008;10(4):e29. PMID: 18926978. doi: v10i4e29 [pii] 10.2196/jmir.1012 [doi].
35. T A, PO V, I N, B R, R J, R H, et al. Chapter 5. Finding Current Best Evidence, in JAMA Users' Guides to the Medical Literature: A Manual for Evidence-Based Clinical Practice, 3nd Edition, McGraw-Hill Medical, 2015. .
36. Yoldi-Negrete M, Morales-Cedillo IP, Navarro-Castellanos I, Fresán-Orellana A, Panduro-Flores R, Becerra-Palars C. Combining Adobe Forms and Dropbox to Obtain a Low-Cost Electronic Data Collection System. Telemed J E Health. 2019 03;25(3):250-6. PMID: 29932811. doi: 10.1089/tmj.2018.0029.
37. Luan A, Momeni A, Lee GK, Galvez MG. Cloud-Based Applications for Organizing and Reviewing Plastic Surgery Content. Eplasty. 2015;15:e48. PMID: 26576208.
38. Iribarren SJ, Cato K, Falzon L, Stone PW. What is the economic evidence for mHealth? A systematic review of economic evaluations of mHealth solutions. PLoS One. 2017;12(2):e0170581. PMID: 28152012. doi: 10.1371/journal.pone.0170581.

39. Badawy SM, Badawy SM, Kuhns LM. Economic Evaluation of Text-Messaging and Smartphone-Based Interventions to Improve Medication Adherence in Adolescents with Chronic Health Conditions: A Systematic Review. JMIR Mhealth Uhealth 2016;4(4):e121 https://mhealthjmirorg/2016/4/e121/. 2016 2016-10-25. doi: doi:10.2196/mhealth.6425.
40. Perski O, Blandford A, Ubhi HK, West R, Michie S. Smokers' and drinkers' choice of smartphone applications and expectations of engagement: a think aloud and interview study. BMC Med Inform Decis Mak. 2017 Feb 28;17(1):25. PMID: 28241759. doi: 10.1186/s12911-017-0422-8.
41. Badawy SM, Thompson AA, Kuhns LM. Medication Adherence and Technology-Based Interventions for Adolescents With Chronic Health Conditions: A Few Key Considerations. JMIR Mhealth Uhealth. 2017 Dec 22;5(12):e202. PMID: 29273573. doi: 10.2196/mhealth.8310.
42. Perski O, Blandford A, West R, Michie S. Conceptualising engagement with digital behaviour change interventions: a systematic review using principles from critical interpretive synthesis. Transl Behav Med. 2017 Jun;7(2):254-67. PMID: 27966189. doi: 10.1007/s13142-016-0453-1.
43. Guidelines IoMUCoSfDTCP, Graham R, Mancher M, Wolman DM, Greenfield S, Steinberg E. COMMITTEE ON STANDARDS FOR DEVELOPING TRUSTWORTHY CLINICAL PRACTICE GUIDELINES. 2011 2011. doi: https://www.ncbi.nlm.nih.gov/books/NBK209544/.
44. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. Bmj. 2008 Apr 26;336(7650):924-6. PMID: 18436948. doi: 10.1136/bmj.39489.470347.AD.

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Prof. Eduardo Schiffer – Team leader, Co-founder of the project and idea, wrote the first draft and critically revised the manuscript, supervised the project.

Prof. Thomas Agoritsas – Critically revised the manuscript, took part in the analyses of results and literature review, took part in the writing of the final draft.

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Conflicts of Interest

none declared.

Abbreviations

API : Application Programming Interface
CS : Clinical skills
ECM : Educational content manager
SD : Standard Deviation
SE : Standard Error

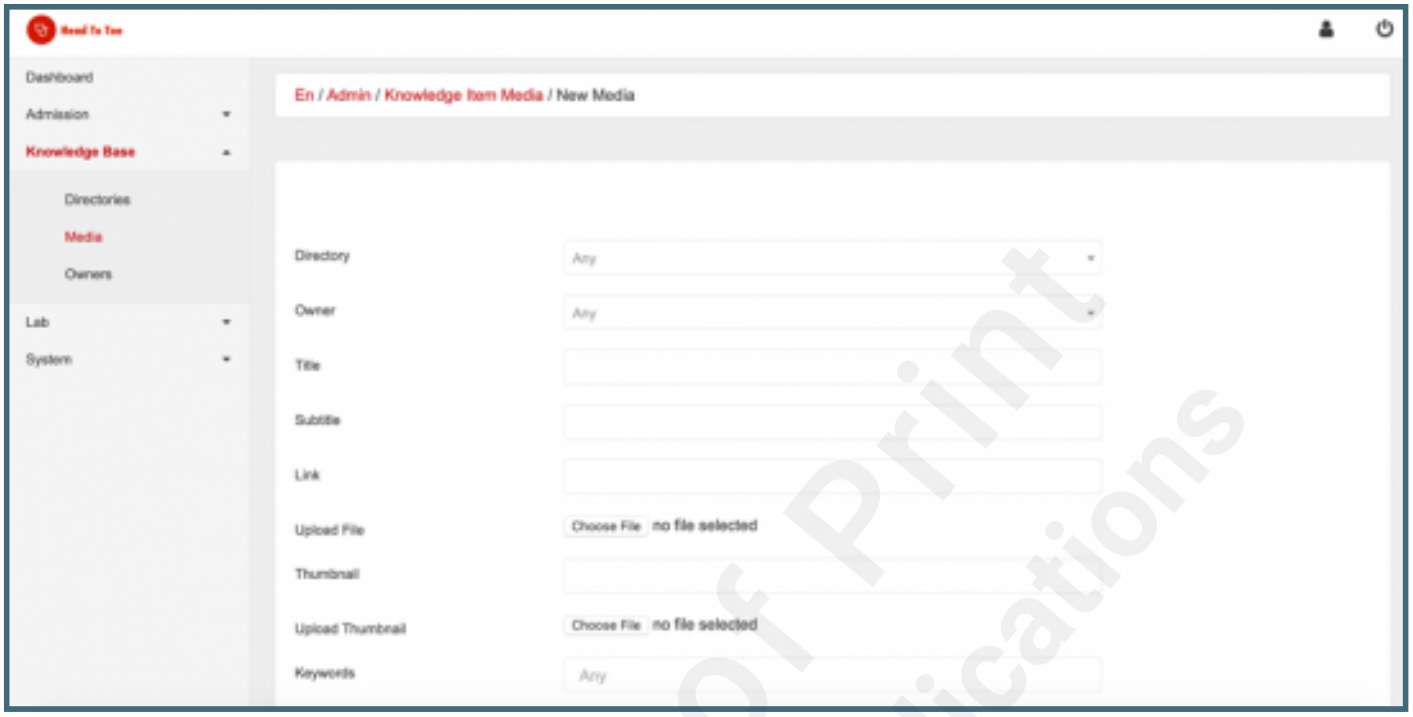
Multimedia Appendix 1

Survey questions

Supplementary Files

Figures

The administration interface of the HeadToToe platform. Educational content managers can use the interface to insert, update, and delete new content. Through the interface, administrators can also create the admission checklist for the admission checklist section as well as the laboratory values section.

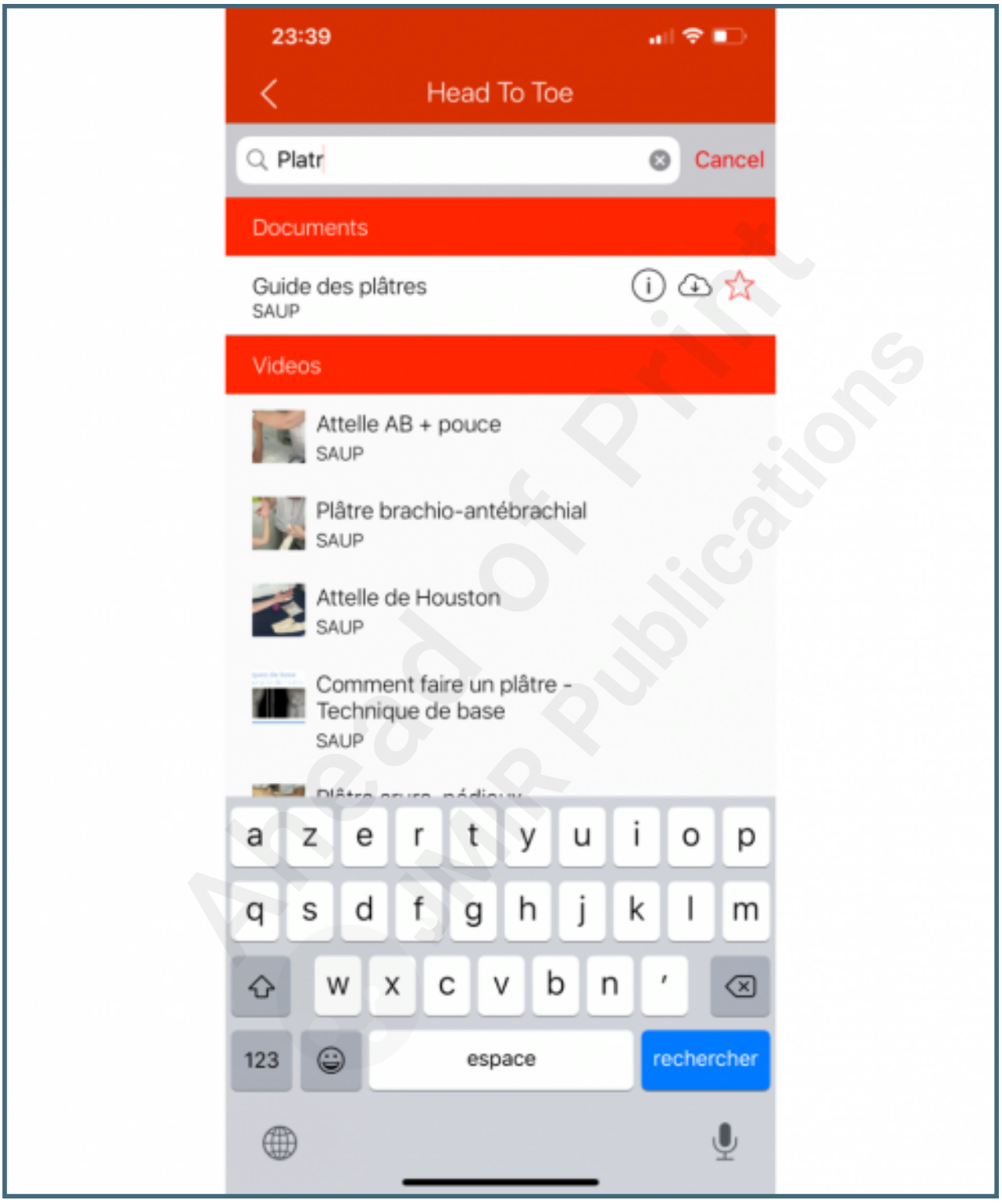


The knowledge base of the HeadToToe platform (in French). Users can navigate through different medical specialties organized as folders.

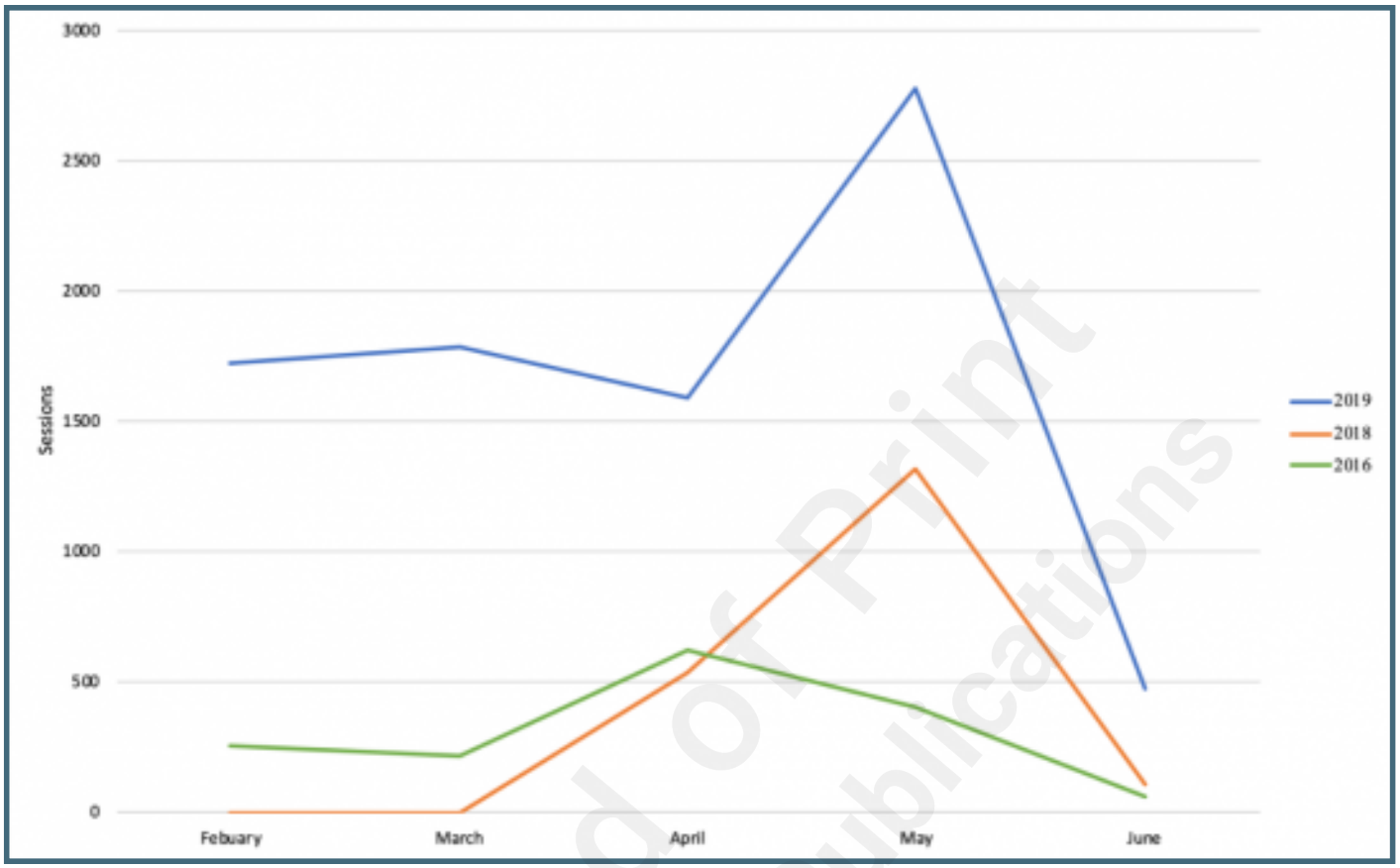
History-taking and clinical examination checklist section in the HeadToToe plaform (in French). Users can consult the list, add comments, and create a PDF with all checked items and added information.

Laboratory values in the HeadToToe platform (in French). Users can consult basic laboratory values validated for local reference values.

The search screen of the HeadToToe platform (in French). Users can search through all types of content from this screen and quickly access needed information.



Exam period usage patterns from 2016 to 2019. Exam period is usually at the end of the spring semester either in the beginning or the end of may each year.



Multimedia Appendixes

Survey questions.
URL: https://asset.jmir.pub/assets/492f924eabafa8868de15e33214bba40.docx

Other materials for editor/reviewers onlies

Responses to editor and reviewers.
URL: https://asset.jmir.pub/assets/fb0d1992e758b39dda91d4d3591185f6.docx