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Organizing and sharing medical knowledge among anesthesiology and intensive care residents: evaluating existing practices and the feasibility of implementing a dedicated multiplatform application

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Abstract**Background.**

Treating patients with up-to-date medical knowledge is an ongoing goal for healthcare workers and implies efficient knowledge management at the point of care. Widely available mobile wireless technologies influence practices but a significant gap remains between technological possibilities and actual usage. The purpose of this study was to analyze residents' baseline practices in managing medical knowledge and to evaluate the use and impact of an innovative multiplatform application dedicated to anesthesiology and intensive care residents.

Methods.

This study took place in Rennes Teaching Hospital and comprised two distinct surveys. First, in April 2018, all residents received a ten-items online survey focusing on managing medical knowledge. Then, through a second online survey constituted of ten items, we sought to assess the use of a new multiplatform cloud-based application named "DansMaBlouse", dedicated to sharing and indexing medical knowledge, in anesthesiology and intensive care residents.

Results.

Among 148 residents that answered the evaluation survey, the most sought out pieces of information in clinical setting were a phone or fax number (74%), drugs' characteristics (68%) and expert guidelines (57%). The main sources were senior staff (68%), medical databases (60%) and an Internet search engine (59%). Computers and smartphones were more frequently used than bound paper notebooks. After implementation of the multiplatform application DansMaBlouse, fifty-nine (82%) of the 72 residents that answered the evaluation survey reported using the application and 39% used it more than ten times. Among application users, 90% found it easy to use and 92% agreed that it improved point-of-care access to knowledge.

Conclusion.

Accessing appropriate medical knowledge at the point of care remains an issue for residents and can be improved by a multiplatform application combining personal and shared up-to-date resources.

Introduction.

Treating patients with up-to-date medical knowledge is an ongoing challenge for healthcare workers. Collecting, summarizing and applying reliable knowledge at the point of care is crucial and time consuming for clinicians. On average physicians find themselves having to seek medical information from an external source every two patients[1,2]. In a study by Green *et al.*, up to 60% of medical residents claimed that time was a major issue when seeking medical information[3] leaving 40% of their clinical questions unanswered[4]. Despite significant advances in information technology and the wide availability of online resources, this efficiency issue remains[2].

Physicians' expectations regarding the ideal knowledge source are high and include efficiency, reliability, accessibility, suitability for use and ability to also give them access to their local workplace's guidelines[5]. Information sources are multiple, dispersed, and always increasing[1]. Different sources vary in content, thoroughness, reliability and pathways to information. Those numerous reasons make their use ineffective and time-consuming, and lead doctors to create personal knowledge databases, commonly as meticulously elaborated notes and article cut-outs. Difficulties in keeping these databases up to date had been reported since 1996 motivating the use of new "electronic, portable, fast, easy to use, connected" tools[6].

Nowadays smartphones and computers are routinely used in the therapeutic and diagnostic setting in many ways[7–10]. Examples may include searching the hospital intranet, the Internet or using mobile medical applications for seeking information (procedures, expert guidelines, dosages, calculators), accessing e-learning courses and creating ePortfolios. As suggested by Baumgart in 2005[11], mobile devices may be efficient tools in daily clinical practice to access and share medical knowledge. Furthermore, it has been suggested that the transition from medical student to newly qualified junior doctor is a "critically intense learning period" and that smartphones play a major role during this phase[12]. For instance, almost all French anesthesiology and intensive care medicine residents carry a smartphone and use it daily for medical purposes through the Internet or specific applications, reporting a substantial feeling of improvement in their therapeutic and sometimes diagnostic skills[13,14].

However, there is a significant gap between using technological tools and actual improvement of knowledge and benefit for the professionals that might be due to the lack of a thorough system, dedicated to health professionals and as easy to use as a pen and paper.

Therefore, we aimed to analyze residents' baseline practices in managing medical knowledge and to assess the use of an innovative multiplatform application by anesthesiology and intensive care residents.

Methods.

Study design & settings

The study was conducted in the Teaching Hospital of Rennes, France (Centre Hospitalo-Universitaire de Rennes), and comprised two distinct surveys. In the first survey, we sought to assess the strategies for searching and indexing medical knowledge among all medical residents of the teaching hospital. In the second survey, the use of a new multiplatform application called "DansMaBlouse", dedicated to sharing and indexing medical knowledge, was evaluated in anesthesiology and intensive care residents. Participants were contacted by e-mail via the residents' mailing list provided by the Rennes University Hospital. The questions in the first survey were drawn up after a scientific bibliography had been compiled to identify the main information collected daily by doctors and the means of sharing and indexing medical knowledge[15,16]. The questions in the second survey were designed to assess the use of a new application, its usefulness and the contribution it could make to indexing and sharing medical knowledge. The questions of both surveys were tested before being sent to participants.

In order to ensure complete descriptions of our survey, the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) was used in this study [17]. Therefore, participation and completion rates were reported. The surveys were set up in LimeSurvey Version 3.6.1+180329 (www.limesurvey.org). The completion of all the items of the surveys was reinforced using Javascript and server-side techniques. Respondents to the two surveys were not able to review and change their answers.

Resident practices at baseline survey

All residents (i.e., 1053 residents) in the teaching hospital of Rennes received a ten-items online survey by email in April of 2018 (one page) (**Supplementary Table 1**). Demographics,

knowledge searching strategies and knowledge indexing strategies were anonymously evaluated. In the demographic section, data were collected regarding training, years of experience and previous use of a beta version of the application. Knowledge searching and indexing strategies were assessed with three multiple-choice questions and four frequency scales designed specifically for the study. Frequency scales ranged between 0 (never) and 10 (frequently). Residents who had previously used a beta version of the application were not included in this analysis. To prevent or detect multiple entries from the same individual, cookies were used to assign a unique user identifier to each participant computer.

Application design

From January 2015 to September 2018, a multiplatform digital pocket book application for healthcare professionals named “DansMaBlouse” was developed with three goals: to help healthcare professionals indexing medical knowledge, to encourage effective sharing of this knowledge and to provide an easy and permanent point-of-care access to any of this information. The ultimate goal was to shift the usual pathways to medical knowledge, from a time-consuming model to an efficient system using mobile devices and cloud-based technology.

DansMaBlouse is a free mobile application (available on iOS since September of 2016 and Android since June of 2017) and a mobile-compatible website (published by DansMaBlouse.fr since January of 2016). A user account is needed to access the two features of the application. The main purposes of the DansMaBlouse application are displayed in **Supplementary Figure 1**.

The first one is strictly personal and allows the creation of a private digital “pocket notebook”. The second one enables collaborative construction of a knowledge database. Users can create or join groups related to their specialty, local work team, fields of expertise, or scientific areas of interest.

Content creation is divided into 4 sets: a notebook containing notes that can be extended with images and files, and organized in categories; a therapeutic thesaurus with a dedicated template (dosage, indications, contraindications, adverse effects, pharmacodynamics and pharmacokinetics, administration protocol); a phonebook; and some medical calculators (Body Mass Index, Glasgow, tidal volume, Sepsis-related Organ Failure Assessment, Richmond Agitation-Sedation Scale, ...). Relevant screenshots from DansMaBlouse are displayed in **Supplementary Figure 2**. The application is cloud-based, all data being synchronized over HTTPS on a remote server. The mobile front-end is developed using Web technologies

(HTML5, CSS3, Javascript), powered by the open-source Apache Cordova mobile framework. A local database using NoSQL technology enables data access in the absence of network connectivity. The back-end is built using dedicated PHP libraries, linked to a MySQL database. Data are stored on OVH servers in France, complying with French data privacy laws.

Assessment of the use of a new multiplatform application in anesthesiology and intensive care residents

As a part of this study, a group named “DESARennes” was created to share knowledge between anesthesiology and intensive care residents at the time of the study. It gave access to the institutional guidelines, educational presentations by residents, medical articles recommended by professors and to the guidelines from the French Society of anesthesia and intensive care, to a dedicated phonebook and to the night duty schedules. Those different items were either already available through the hospital’s intranet, received via email or not available at all.

Participants and recruitment

All anesthesiology and intensive care residents working at the teaching hospital of Rennes (n=79) from September 2018 to January 2019 were contacted by email on September 19th, 2018 and encouraged to use the DansMaBlouse application. The email contained a short description and a user guide to the application. No request or reminder to use the application were sent. Each resident was provided access to the shared group “DESARennes”. This system did not replace other pre-existing methods for sharing knowledge between doctors in training. Participation and completion rates were reported.

Evaluation survey

All anesthesiology and intensive care residents were invited to take part in the survey received via email at the end of the experimentation (January 27th, 2019), whether they had used the application or not. It was an anonymous online survey designed for this study with 12 items (three pages) including 2 specific items for residents who had not used the application and 6 for residents who had used it (**Supplementary Table 2**). One reminder was sent out on February 2; 2019 for this survey with a unique invitation token for participants (unique participation link). Opinions were reported using a 5-point Likert scale.

Ethical considerations

As this study formed part of a quality improvement program, ethical approval was not sought from the institutional review board. Potential participants in both surveys were informed and invited by email and could opt out of participating in the surveys, as participation in the surveys was voluntary. No personal data was collected and survey responses were anonymized and stored in the professional computer of the investigator. No incentives were offered for taking part in the surveys.

Statistical analysis

Responses were recoded to simplify opinions when appropriate: for example, 'strongly agree' and 'agree' were aggregated, as were 'strongly disagree' and 'disagree'. Means and standard deviations (SD), medians and interquartile ranges (IQR) or absolute and relative frequencies (%) with their 95% confidence interval (95 CI) were reported when applicable. No statistical method was used in order to adjust for the non-representative sample. The data were analyzed utilizing R version 3.5.2.

Sample size

As the evaluation of residents' practices in terms of indexing and sharing medical knowledge had not previously been established, no data was available concerning the expected results for each survey in order to determine the sample size required for the two surveys.

Results.

General characteristics of the surveys

Responses were collected first from April 9, 2018 to May 3, 2018 for the first survey in all residents (n=1053) of the Rennes University Hospital and then from January 27, 2019 to February 3, 2019 for the second survey only among anesthesiology and intensive care residents (n= 79). The participation rates and completion rates were 16.0% (169/1053) and 15.6% (164/1053) in the first and 96% (76/79) and 91% (72/79) in the second survey, respectively.

Residents' strategies at baseline survey

In the first phase, 164 residents of the teaching hospital of Rennes completed the baseline survey. Sixteen residents (9.7%) were excluded from analysis because they had already used the beta version of the application. The most sought out pieces of information by residents in everyday practice were a phone or fax number (74%), drugs' characteristics (68%) and expert guidelines (57%) (**Table 1**). The three main sources of information were senior staff or specialists (68%), medical databases (60%) and an Internet search engine (59%). The most frequent searching tools used in daily practice were computers (Likert scale score 10 [IQR 7 - 10]) and smartphones (Likert scale score 6 [IQR 3 - 9]), while bound paper notebook appeared less commonly used (Likert scale score 4 [IQR 1 - 6]). Indexing a new knowledge (i.e., adding a new scientific article or protocol to the library) was not rare (Likert scale score 5 [IQR 3 - 7] on frequency scale from 0 to 10) but no indexing tool was predominantly used.

Application evaluation survey

Seventy-two residents included completed the evaluation survey. Eighty-two per cent used the application (**Table 2**) and 39% used it over ten times. Among the application users, 90% found it easy to use, 92% agreed that it improved point-of-care access to knowledge but only 37% agreed that it was helpful for indexing knowledge (**Table 3**). Residents found the application useful during their residency (98%) and assumed it would also be useful after the end of their training (78%). Fifty-eight per cent of all residents felt that the application would have been more useful with more features or more content and 30% if the application had been easier to use or if a more extensive user guide had been provided.

The main reason cited regarding residents who did not use the application was already having a personal strategy to search (77%) or to index (54%) knowledge (**Table 4**). Seventy-seven per cent of this group found they would have used the application if it had been available at the beginning of their training.

Discussion.

In the present study, we found that the three most sought-out pieces of information by residents were a telephone or fax number, drug characteristics and expert guidelines, while the three main sources of information were senior staff or specialists, medical databases and an Internet search engine. The implementation of a new application dedicated to indexing medical knowledge in a sub-group of residents (anesthesiology and intensive care residents) was reported to improve access to knowledge at the point of care.

Everyday practice raises numerous medical questions and physicians' information-seeking behaviors have been extensively studied. With each patient an average of 0.57 questions arise, at any moment of a 24 hour-shift and predominantly related to disease management or medication[2,18]. Many different sources of medical information are used by residents in the clinical setting. As identified by previous studies, the most used ones are human and digital resources[1,19,20]. This diversity conveys the lack of an "ideal" system allowing for successful and efficient searches. Many obstacles to information seeking have been brought to light: lack of time (clinicians spend an average of under 3 minutes seeking a piece of information) and suspected lack of an existing pertinent answer[2]. After a successful clinical information search, we observed a low indexing rate: we presume that lack of time may be an important factor. Regarding means of indexing, our population opted for digital tools over handwritten notebooks and loose sheets.

Digital tools are also preferred for information retrieval by residents. It was shown that residents more than others (students, attendings, senior staff) used their smartphones for medical information seeking, several times a week for the majority of them[16,21,22].

Feedback on the application

A large majority of anesthesiology and intensive care medicine residents reported having tried the application after being solicited by email, this data being consistent with the available application usage statistics. Few residents did not use the application during the study: they reported already having a personal way to access and index knowledge. Those residents also mentioned that they would have considered using the application if it had been available at the beginning of their training. Almost all residents reported a strong sense of utility of the application for a doctor in training, mainly because it facilitates knowledge access at the point of care. Seventy-eight per cent of the residents felt that they would benefit from using the application even after the end of their training.

These results are in accordance with the success of the DansMaBlouse application within the French-speaking healthcare professionals' community. In fact, in parallel with our study,

DansMaBlouse has been publicly available as a free app since January 2016. It has been downloaded by over 34.000 health professionals, of whom 30% are doctors, 48% nurses, the remaining 22% comprising other healthcare professionals or students. Among these users, there are nearly 3.000 healthcare professionals working in the field of anesthesiology (doctors, residents and nurses). 630 user groups have been created, including hospital departments, care networks and student groups. Some hospitals have implemented DansMaBlouse to distribute their protocols to their staff. Many applications dedicated to anesthesiology workers have been developed in recent years, and are used in daily practice particularly by the anesthesiology attendings and residents[23]. Developing technologies has played an important role in the evolution and safety improvement of clinical anesthesiology[14,24]. Evidence-based recommendations exist regarding many clinical situations and should be readily available at the point of care, even when the point of care fluctuates in the anesthesiology practice: different operating rooms, intensive care units, consulting offices, an urgent intervention in a different department of the hospital or clinic, or the pre-hospital emergency setting. Handheld computers can be particularly suitable for a portable, easy and fast access to information, which would account for the significant use of the application by anesthesiology healthcare professionals. Along the study period, we also observed the creation by different medical or paramedical teams of groups of shared knowledge dedicated to their department, hospital, training institute or field of practice. This was not part of the experimentation but could account for the success of the application in our population.

There were two main obstacles to the use of smartphones by residents reported in previous studies[16]. The first one was limited wireless Internet access in the workplace. With our system, the use of cloud data synchronization on a remote server allows resources to be available offline. The second obstacle reported was not knowing which contents are available online. The unique feature of DansMaBlouse is that the content may be added and updated by the user. It enables the user to bring together personal knowledge from their own learning or experience, and shared knowledge from collaborative groups. As a result, they would know which pieces of information are available on the application.

Previous studies identified criteria strongly associated with the ability of a knowledge indexing and retrieval system to improve clinical practice. The design of our application meets 3 of the 4 criteria: knowledge access at the time and location of decision-making, availability of actionable recommendations, and computer-based use[25]. The fourth criteria would be automatic provision of information as part of the clinician's workflow. Our application however

is not meant to collect any patient data. Thus, such a decision support tool is structurally incompatible with our system.

Smartphone use in the clinical setting

In our study we take into account the use of smartphones in the clinical setting. In France, the use of mobile phones in health structures was at first prohibited due to the theoretical risk of electromagnetic interferences[26]. In 2016 however the French health administration authorities (French Agency for Food, Environmental and Occupational Health & Safety) issued a favorable opinion towards smartphone use by healthcare workers in the professional setting[27]. Numerous studies have focused on the nosocomial infection risk associated with carrying a smartphone, especially in operating rooms [28–31]. In those studies phones tended to be potential vectors for disease: this should be confirmed and put in perspective with the risk associated with other information and communication media also found in the workplace (Digital Enhanced Cordless Telecommunications, pocket notebooks, folders...). Another theoretical concern is that residents in training may rely on their smartphones only, without acquiring the basic fundamentals of their specialty, assured that they can always rely on their device[32].

To our knowledge, this is the first study to develop a collaborative and cloud-based technological intervention aimed at improving knowledge access at the point of care for anesthesiology and intensive care residents. During the development process, designing a system dedicated to the needs of healthcare professionals led to a multiplatform application that proved user-friendly and appealing to medical residents.

The critical role of the user, being the main builder of their own information storage and retrieval tool, is a first but may also be a drawback. Indeed, the application content would vary according to the user. The content would also depend on the level to which the application is implemented in the environment, *i.e.* how much professional shared knowledge is made available for users among a team, a department, a hospital through this application. The issue of the content's quality must be taken into consideration. The accuracy of personal content can be compared to that of usual practices. For example, a handwritten notebook, loose sheets or articles cut-outs may only rarely be updated. Regarding groups, their collaborative construction leads to constraints already encountered in other comparable systems[33]. In our application, the content of groups cannot be edited by any user. It is under the responsibility of the group's administrators and editors, complying with the quality and safety policies of their institutions. The elaboration of a code of good practice within the application could be considered.

In the end the impact of the application is likely to vary from one user to another, making its assessment difficult. Although the application seemed well-received by our small sample of users, its impact on the quality of care at a larger scale remains to be studied.

Some limitations of our study must be acknowledged. First, our assessments are based on surveys that may have a participation bias. Beyond this bias inherent to the design of the study, the evaluation of the performances of this application on the efficiency of the residents can only be fragmentary given the complexity of the evaluation of the efficiency of scientific documentation research as well as the performance of the residents. Second, we did not use any standardized questionnaires such as the PSSUQ (Post-Study System Usability Questionnaire). Finally, the absence of a gold standard for the functionalities offered by the application does not allow any comparison.

Conclusion.

This study emphasizes the on-going difficulty for medical residents to access appropriate medical knowledge at the point of care, and the need for effective dedicated systems. The implementation for anesthesiology and intensive care medicine residents of an innovative multiplatform application combining personal and shared up-to-date knowledge seemed effective and well-received. Future studies may explore ways to improve effectiveness in point-of-care knowledge management through dedicated systems, leading to appropriate usage by doctors in training and better patient care. Determining the actual clinical impact of such practices on patients' health is the next step.

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Declarations section

Ethics approval and consent to participate

Although the survey was not approved by an institutional review board, potential participants in both surveys were informed and invited by email and could opt out of participating in the surveys, as participation in the surveys was voluntary. No personal data was collected and survey responses were anonymized and stored in the professional computer of the investigator. No incentives were offered for taking part in the surveys.

Consent for publication

Not applicable

Availability of supporting data

The datasets from this study are available from the corresponding author on request.

Competing interests

The authors report no conflict of interest related to this work

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Author contributions

G.Ri., G.Ro., and H.B. conceived, designed, coordinated the data collection and supervised the study. G.R. performed the statistical analysis. G.Ri., G.Ro., F.R., and H.B. wrote the first draft of the article. All authors approved the final version of the manuscript.